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Remote control of shortwave and mediumwave transmitters by means of a processcomputer

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1 Introduction

The shortwave service of the Swiss Broadcasting Corporation produces a programme for Europe, which is transmitted at the following frequencies:

3.985 MHz (75.28 m) 6.165 MHz (48.66 m) 9.535 MHz (31.46 m)

The PTT provides and operates the appropriate transmitter equipment. Since existing installations were due to be replaced, two new transmitter stations were constructed at Sarnen and Lenk during the past few years. The transmitter station at Lenk comprises two shortwave transmitters and that at Sarnen one shortwave and one mediumwave transmitter.

The three shortwave transmitters are constructed in the most modern way and their technical data are as follows:

- Carrier power 150 kW or 250 kW
- Frequency range 5.9...26.1 MHz
- Automatic tuning of the HF circuits
- Time required for frequency change less than 60 s

Together with two older transmitters at the manned transmitter station at Beromünster, these new installations are used to broadcast the European Programme. The two transmitters at Beromünster serve as standby transmitters. They also have a carrier power of 250 kW.

The mediumwave transmitter at Sarnen is used to broadcast the First Programme of Radio DRS (German and Romanish speaking parts of Switzerland) during the morning, evening and night. A vertical beam transmitter sends the radio waves directly in the direction of the ionosphere where they are reflected. This method allows the whole of Switzerland to be covered uniformly.

In contrast to the local VHF radio service, the locations of the transmitters referred to are not geographically confined which has enabled decentralisation. However, since the transmitters are located at different sites and have to operate unattended, a central control and monitoring station is required.

2 The tasks of the control and monitoring station

The central control and monitoring station performs a wide range of different control and monitoring functions among which there exists a hierarchical relationship. In order to carry out these tasks, a processor is used whose principal functions are described below.

21 Control and monitoring of transmitter operation

The processor controls and monitors the individual transmitters in accordance with an operating plan which defines the transmitters being used, the power, the frequency and the transmission times of the respective radio programmes. It must be possible at all times to take into account deviations from the operating plan, e.g. in the case of faults or of work on and maintenance of the transmitters, aerials, infrastructure, etc., and to process these deviations as rapidly as possible. Certain modifications of the operating plan are preprogrammed; others can be entered into the processor at any time, thus allowing prevailing conditions to be taken into account at all times in the monitoring and control of the total operation.

22 Control and monitoring of the individual transmitters

The instructions for the *shortwave transmitters* comprise

- Switching on the 150 kW power
- Switching on the 250 kW power
- Loading of the frequency store
- Connection of one of six frequency stores
- Frequency change
- Switching off the installation

The processor controls the instruction routines and monitors their execution. In addition, special checks are made on the power, frequency and carrier modulation. The subsequent transmitter operation is monitored over time. This control programme enables the transmitters to be used for any desired frequency and power.

The control of the *mediumwave transmitter* is slightly simpler because no automatic frequency change is required.

23 Infrastructure

The operation of high power transmitters at a transmitter station requires an extensive infrastructure which comprises amongst other things the following equipment:

- Power supply 16 kV/380 V from the mains
- Power supply 16 kV/380 V by means of two 1000 kVA diesel generators for the transmitters and one 300 kVA diesel generators for the auxiliary equipment
- Tank installations for the fuel used by the diesel engines
- Cooling and air conditioning installations

- Alarm installations for fire, water and oil
- Automatic CO2 extinguishers
- Control equipment

In order to save energy costs, the diesel generators — which are also used during mains outages — are switched on during the peak energy periods. During this time, the energy which is not taken from the mains is available to the power generating station. The energy supplier takes this into account in fixing the tariffs. In addition, this method of operation allows us to make more efficient use of our equipment. The remotely controlled operation of the installations comprising the infrastructure requires predominantly monitoring functions and only a small number of control functions.

24 Maintenance of the transmitter stations

The Radio and Television Department of the Regional Telephone Directorates within whose service areas the transmitter stations are located are responsible for the maintenance and fault-clearing in these installations. This means that the service stations must be in possession of all the requisite information. In addition to comprehensive alarm reports, the service stations receive additional data which enables them in many cases to carry out specific fault clearing operations or to take preventive action which has the effect of saving costs.

The selected data is distributed to the service stations by the control and monitoring station.

25 Printout

The operational sequences are logged and stored on a data medium. Different types of printouts can be obtained at any time both at the control and monitoring station and at the service stations. The stored data are intended for long term processing. All printouts are written in clear text.

3 Remote control and remote monitoring

31 Processor

The size of the data volume and the extent of the control and monitoring functions outlined, necessitate the use of a mini-processor with disc store and tape unit.

32 The principle of remote control

Figure 1 shows the structure of the processor hardware. As the Figure shows, the computer is connected to the transmitter stations via interfaces and remote action equipment TG 707 (Landis & Gyr, Zug); the service stations are connected to the computer via terminals.

The information data of the transmitter stations are stored as a process image in the core storage of the computer; a disk-storage unit contains the processing programs. Changes in the process image are then sensed and processed by the appropriate programs. The processes and functional sequences which result are stored on tape and recorded at the terminals as operational printouts. The output of the instructions is again

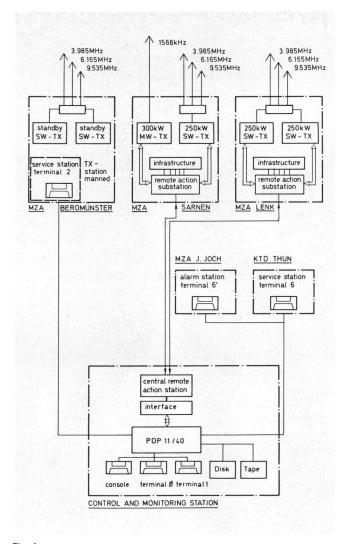


Fig. 1
Structure of the processor hardware

carried-out via the remote action equipment. The terminals allow intervention in the operation.

The data to be transmitted has been standardized. There are four typical kinds of information. In the *direction of reporting*, i.e. from the transmitter stations to the control and monitoring station

- Analog measurement values (70 per transmitter station)
- BCD counter values of 6 decades each (4 per transmitter station)
- Alarms and indications (280 per transmitter station)

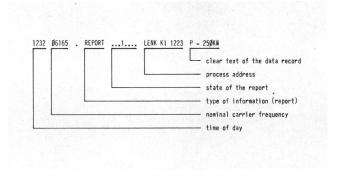


Fig. 2
Data record of a report

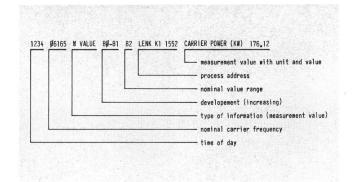


Fig. 3

Data record of a measurement value. For transmitter operation at a carrier power of 250 kW, range B2 is the nominal value range, the data record being printed out when the limits are transgressed

In the *direction of instructions*, i.e. from the control and monitoring station to the transmitter station,

 individual commands (98 per transmitter station) are transmitted.

A separate computer element called data record exists for each of these individual items of information. Specific data records are combined to form process areas and the latter are in turn combined to form files. For example, all the data records and process areas of a transmitter form a file. If the data record is processed, one or more printout lines result which form the basis of various printouts. The format of the printout line is adapted to the process and is also standardized.

33 Examples of printout lines

- Printout of a data record of a report (Fig. 2): The shortwave transmitter 1 of the Lenk station reports that it has been switched on at 12:32 hrs for radiating the carrier power $P=250\,$ kW at the frequency of 6.165 MHz.
- Printout of a measurement value data record (Fig. 3):
 The carrier power of the shortwave transmitter 1 of the Lenk station has transgressed the lower limiting value (in the direction of increase) at 12:34 hrs (Fig. 4).
- Printout of an instruction data record (Fig. 5): The instruction for switching on at a power of P = 300 kW was given to the mediumwave transmitter of the station at Sarnen by the computer time programme at 05:50 hrs.

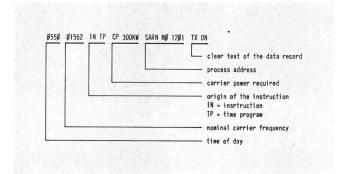


Fig. 5
Data record of an instruction

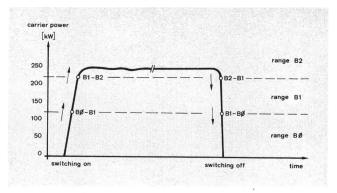


Fig. 4
Temporal process of carrier power. For transmitter operation at a carrier power of 250 kW, range B2 is the nominal value range, the data record being printed out when the limits are transgressed

 Printout of frequency data record (Fig. 6): The carrier frequency of the shortwave transmitter at Sarnen has exceeded the limiting value (+50 Hz) because, for example, a decade of the frequency synthesizer is not synchronizing.

34 Operational printout

The operational printout is generated spontaneously and reflects the operating sequence of all the installations.

By means of special symbols, alarms are optically emphasized, the staff being called to the terminals by acoustic signals.

The following three alarm stages are distinguished:

- Non-urgent alarm: \$ NDAL means, for example, that transmissions are jeopardized because of a fault in the transmitter. The transmitter station must be visited within the next few days.
- Urgent alarm: *DRAL means, for example, that the transmission has been interrupted because of a fault in the transmitter. A standby transmitter must be put into operation immediately. The transmitter station must be visited.
- Emergency alarm: # NOTAL requires, for example, intervention by the fire brigade. The transmitter station must be taken out of service and visited without delay. Figure 7 shows an extract from an operating printout (terminal at Thun).

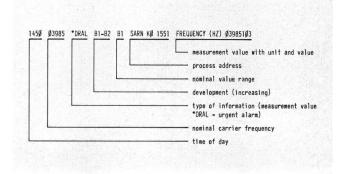


Fig. 6
Data record of a frequency value

12. 01	70							
0601	. 70	MELD	1	LENK	EV	1321	HOCHTARIF NETZ	
	03985		PT. 250KW				TX EIN	
	03985						HS SCHALTER KWS 2	
	03985	MELD	1			1321		
0635	03985	NDAL	1			2227		
0635	03985	BEFEHL	AUSGEFRT		K2	2401	BETRIEB F1 3.985 MHZ	
	03985		1	LENK		1221	TX STANDBY	
	03985		1			1223	TX P 250KW	
0636	03985	. NDAL		LENK		2227	BUCHHOL ZSCHUTZ	
0636	03985	BF AUT	M WERT	LENK	K2	1571	TRAEGERLEIST. (KW)	264, 50
0636	03985	BF AUT		LENK			FREQUENZ (HZ)	03985000
0645	03985	. DRAL	0			1231	KEINE NF AUSG TX	
0645	06165	BF AUT	PT. 250KW	LENK	KI	1201	TX EIN	
0645	06165	. MELD	1	LENK	K1	1239	HS SCHALTER KWS 1	
0645	06165	. MELD	1	LENK		1322		
0646	06165	BEFEHL	AUSGEFRT	LENK	K1	2402	BETRIEB F2 6. 165 MHZ	
	06165	. MELD	1			1221	TX STANDBY	
0646	06165	. MELD	1	LENK	K1	1223	TX P 250KW	
		BF AUT		LENK	K1	1571	TRAEGERLEIST. (KW)	261.05
		BF AUT		LENK	K1	1570	FREQUENZ (HZ)	06165000
	03985	. DRAL		LENK			KEINE NF AUSG TX	
	06165	BF ZT	M WERT	LENK	K1	1571	TRAEGERLEIST. (KW)	263, 35
	03985	BF ZT	M WERT	LENK		1571		267. 95
	06165		1			2222	WASSER NACHFUELLEN	
	06165		0				WASSER NACHFUELLEN	
1016			D2 1				ZYLINDERTEMP. UNGLEICH	
1017			D2 O				MIN PEGEL SCHMIEROEL	
1022							ZYLINDERTEMP. UNGLEICH	
1023			0	-	IF		GEMEINDEWASSERVENTIL	
1023				LENK	IF	1725		
1023			0		IF	1727		
	03985			LENK		2225	DAMPFUEBERDRUCK	
	03985		1			2222		
	03985			LENK		2222		
1039			D2 1		EV		MAX PEGEL SCHMIEROEL	
1040				LENK			GEMEINDEWASSERVENTIL	
1040			0				GEMEINDEWASSER >7ATUE HALLENBADVENTIL	

Fig. 7
Extract from an operating printout (see text for explanation)

35 Printout of the process areas

Printouts of this kind can be produced by all the terminals. This is done, for example, if information regarding the condition of specific parts of the installation is required as the following examples demonstrate:

- Example 1 (Fig. 8): One wishes to know the nature of the operating measurement values of the RF and AF stages of the shortwave transmitter at Sarnen in order to obtain a picture of the technical condition of the installation.
- Example 2 (Fig. 9): This printout shows measurement values of the 16 kW feed of the transmitter station at Lenk.

PR S	ARNKO	15							
1224	09535			SARN	KO	1500	HF MESSWERTE		
1224	09535	M WERT	B0-B1 B1	SARN	ко	1551	FREQUENZ (HZ)		0953500
1224	09535		B0-B2 B2	SARN	KO	1552	TRAEGERLEIST. (KW)	253.2
1224	09535	. MELD	B0 B0	SARN	KO	1553	VSWR (1)+1		0.0
1224	09535	M WERT		SARN	KO	1554	IC HI (A)		1.4
1224	09535	M WERT		SARN	KO	1555	IC H2 (A)		27.8
1224	09535			SARN	KO	1560	NF MESSWERTE		
1225	09535	M WERT		SARN	KO	1561	IC V3 NI (A)		3.1
							IC V4 NI (A)		4.0
1225	09535	M WERT		SARN	KO	1563	UA HS GR (KV)		13.6
1225	09535	M WERT		SARN	KO	1564	KUEHLUNG H20 (G	RAD C)	38.5

Fig. 8
Extract from a printout relating to the operating measurement values of the AF and RF stages

PR LENKEV				
1341		LENK EV 14	OO MESSWERTE STARKSTROM	
1341	M WERT	LENK EV 14	51 SAMMELSCHIENE 16KV R	14.07
1341	M WERT	LENK EV 14	52 SAMMELSCHIENE 16KV S	14.00
1341			53 SAMMELSCHIENE 16KV T	14 - 14
1341	M WERT	LENK EV 14	54 WIRKLEISTUNG NETZ (KW)	1148.07
1341	M WERT	LENK EV 14	55 COSINUS (16KV SEITE)	0.66
1341			56 WIRKLEISTUNG HILFSBETR	49.92

Fig. 9
Extract from a printout relating to the measurement values of the 16 kV feed

36 Situation printout

Situation printouts are composed of preselected data records of different files and process areas.

Example (Fig. 10): One wishes to know how the shortwave transmitters of the stations at Sarnen and Lenk are being used at present. The printout shows that

- the shortwave transmitter at Sarnen is operating at a power of 259 kW and a frequency of 9.535 MHz at the antenna
- the shortwave transmitter 1 at Lenk is operating with the dummy aerial, i.e. maintenance work is being carried out

Key to	Figure 7 (relating to digits in last column)	12
		1321
1	High tariff meters switched on by Regional	
	Power Station mains command	
2	Processor gave instruction to transmitter 2 for	22 and 23
	operation at carrier power of 250 kW and fre-	
	quency of 3.985 MHz	24 and 25
3	Transmitter connected to 16 kV high voltage	
4	Frequency store with frequency of 3.985 MHz	26
	connected	
5	Monitoring criterion of transmitter 2 has been	27 and 28
	actuated	29 and 30
6	Acknowledgement that the transmitter is tuned	
	to the correct frequency	
7	The transmitter assumed the STANDBY posi-	31
	tion	
8	The transmitter assumed the OPERATION posi-	
	tion at 250 kW	32
9	Monitoring criterion of transmitter 2 reset	
10	Automatic power check after switching-on se-	33 and 34
	quence	35
11	Automatic frequency check after switching-on	
	sequence	
		3638

Resetting of modulation control Switching-on sequence of transmitter 1 for operation at a power of 250 kW and a frequency of 6.165 MHz 23 Printout of carrier power of both transmitters for statistical purposes 25 The boiling/cooling system of transmitter 1 has topped up with cooling water The 1000 kVA diesel installation 2 is faulty; the cylinder loading is not uniform 28 The installation alarms have been reset 30 The drawing of water from the communal reservoir has been prohibited because of a fall in pressure The warm water from the transmitter cooling system is no longer being routed to the heating system of the indoor swimming pool at Lenk The boiling/cooling system of transmitter 2 has been overloaded 34 See 24 and 25 The upper level of the lubricating oil of the 1000 kVA diesel installation 2 has been ex-Since the pressure of the communal water

> supply has returned to normal, water may be taken again; the heated cooling water is again routed to the heating system of the Lenk in-

door swimming pool

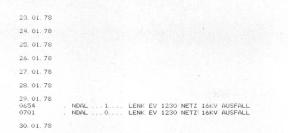


Fig. 10 Extract from a situation printout

 the shortwave transmitter 2 at Lenk is operating at a power of 270 kW and a frequency of 3.985 MHz at the antenna

37 Transmitter station printout

The operating printout is also stored on a data medium. Thus it is possible to call up the data for various purposes and to compile it into different transmitter station printouts as required.

Example (Fig. 11): One wishes to know whether and when mains outages had to be recorded at the transmitter station at Lenk between 23. 1. 1978 and 30. 1. 1978. A special programme finds out whether the data record in question was activated during the period mentioned. The printout accordingly shows that a mains outage took place on 29. 1. 1978 from 06:54 to 07:01 hrs.

The printout in *Figure 12* shows that the 1000 kVA diesel installation 1 was additionally in operation from 06:56 to 07:33 hrs on 29. 1. 1978 because a transmitter had to be switched on during the mains outage mentioned above. The remaining operating times of the installation correspond to the supply of energy during peak periods.

4 Software - Summary

The software consists of various building blocks among which a specific hierarchical relationship exists. The most important software modules are

- The operating system RSX-11-B; this is a real-time executive system which operates according to priorities.
 The programs in the lowest priority stage are run in time sharing operation
- The data bank which contains the process image and the numerous data record files with parameters for processing
- The handlers for transfer and input/output of the process data as it arises
- The programs for operating the system, the on-line program modification, the time program, etc.

Alterations of the data record files can be carried out with any need to interrupt the computer process. Major alterations of data records and new data records are produced on a different computer. The new file part can be substituted for the old one «on-line» under certain conditions. Thanks to the modular structure of the software, alterations to the software can also be performed easily.

```
51 EUROKW
ZUSTANDSPROTOKOLL EUROKW

1339 09535 M WERT B0-BI BI SARN KO 1551 FREQUENZ (HZ) 09535000
1339 09535 ...... B0-B2 B2 SARN KO 1552 TRAEGERLEIST. (KW) 259.20
1340 06165 M WERT B2-BI BI LENK KI 1551 FREQUENZ (HZ) 06165010
1340 06165 ..... B0-B2 B2 LENK KI 1552 TRAEGERLEIST. (KW) 257.60
1340 03965 M WERT B2-BI BI LENK KI 1222 IST AUF DER KUNSTANT.

1340 03965 M WERT B2-BI BI LENK K2 1551 FREQUENZ (HZ) 03985000
1340 03985 M WERT B2-BI BI LENK K2 1552 TRAEGERLEIST. (KW) 270.25
```

Fig. 11
Extract from a transmitter station printout

5 Concluding observations

The operating experience gained so far shows on the one hand that the requirements made of the transmitters, installation control equipment, auxiliary equipment, infrastructure, protective measures etc. are stringent. Remote control is useful only if the instructions it transmits are carried out. On the other hand, the remote control system is not always available because of technical faults which may arise in the computer, remote action equipment, lines, etc. It is therefore an obvious step to require that unattended transmitter stations must continue to operate even without remote control in accordance with the mode of operation indicated by the last instruction received.

Initial difficulties in various installations have been eliminated. Operational security is good.

The technical staff find fault location in unattended transmitter stations more difficult because their «relationship with the installations» is less close than their relationship with the staff in a manned transmitter station. In this connection, the operational printouts produced by the processor perform a valuable service in that they can be used to reconstruct processes such that the causes of faults are found more rapidly.

The record of operation of the last few years has shown that it is possible to operate complex transmitter installations unattended and by remote control with good operational results.

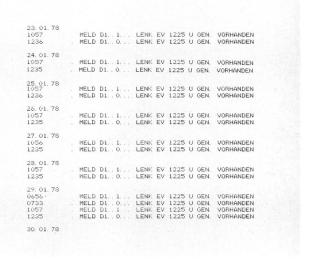


Fig. 12
Extract from a printout relating to the operating time of the 1000 kVA diesel installation 1