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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 CO_2 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

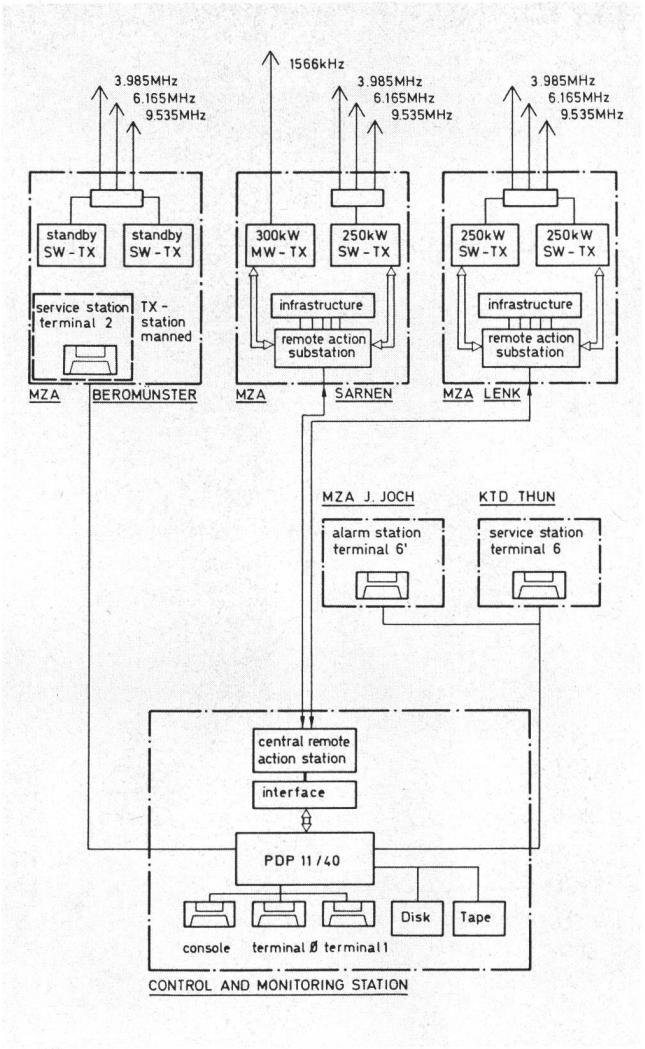


Fig. 1
Structure of the processor hardware

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)

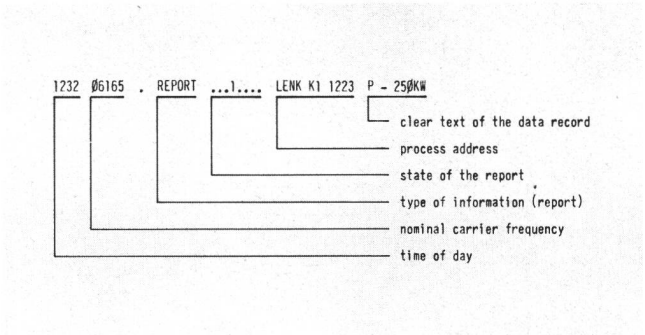


Fig. 2
Data record of a report

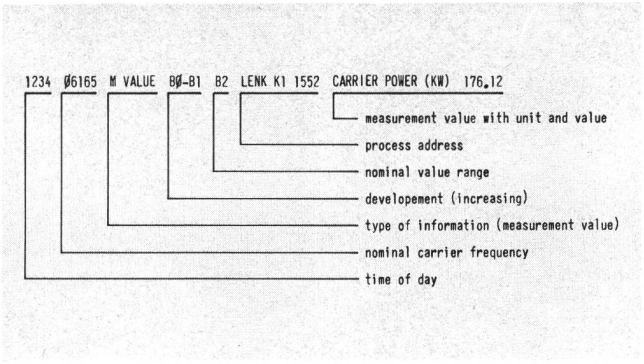


Fig. 3
Data record of a measurement value. For transmitter operation at a carrier power of 250 kW, range B2 is the nominal value range, the data record being printed out when the limits are transgressed

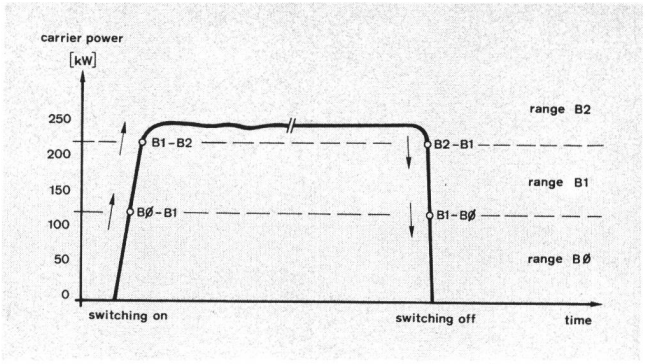


Fig. 4
Temporal process of carrier power. For transmitter operation at a carrier power of 250 kW, range B2 is the nominal value range, the data record being printed out when the limits are transgressed

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.
- 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).

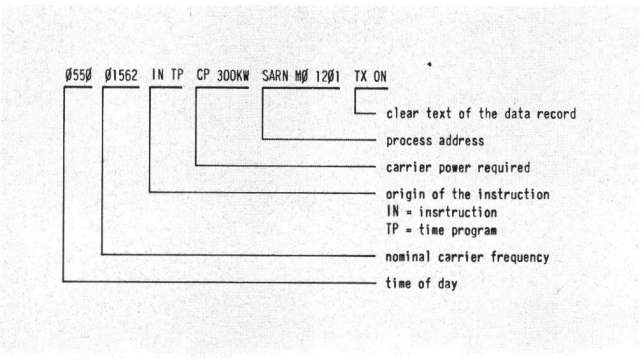


Fig. 5
Data record of an instruction

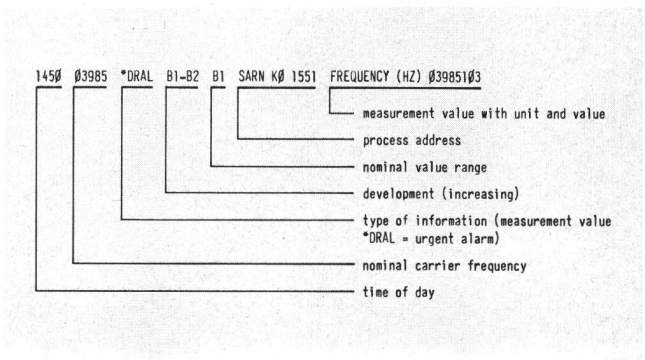
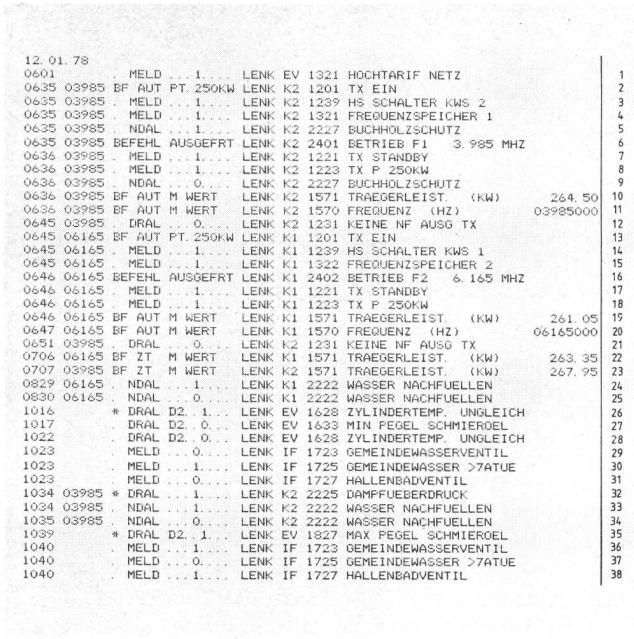


Fig. 6
Data record of a frequency value



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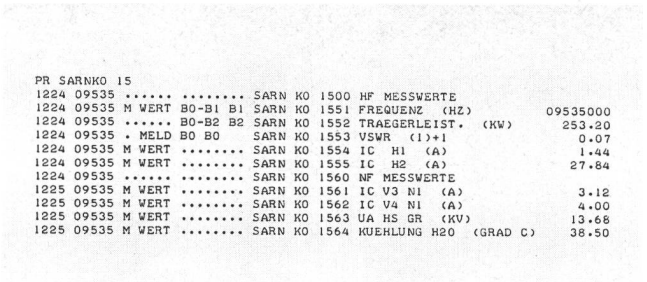
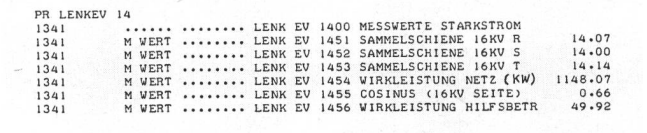
12. 01. 78
0601        . MELD  . . . 1. . . .  LENK EV 1321 HOCHTARIF NETZ                    1
0635 03985 BF AUT PT. 250KW LENK K2 1201 TX EIN                                    2
0635 03985 . MELD  . . . 1. . . .  LENK K2 1239 HS SCHALTER KWS 2                  3
0635 03985 . MELD  . . . 1. . . .  LENK K2 1321 FREQUENZSPEICHER 1                 4
0635 03985 . NDAL  . . . 1. . . .  LENK K2 2227 BUCHHOLZSCHUTZ                     5
0635 03985 BEFEHL AUSGEFRT LENK K2 2401 BETRIEB F1   3.985 MHZ                   6
0636 03985 . MELD  . . . 1. . . .  LENK K2 1221 TX STANDBY                         7
0636 03985 . MELD  . . . 1. . . .  LENK K2 1223 TX P 250KW                         8
0636 03985 . NDAL  . . . 0. . . .  LENK K2 2227 BUCHHOLZSCHUTZ                     9
0636 03985 BF AUT M WERT   LENK K2 1571 TRAEGERLEIST.   (KW)      264.50         10
0636 03985 BF AUT M WERT   LENK K2 1570 FREQUENZ  (HZ)          03985000         11
0645 03985 . DRAL  . . . 0. . . .  LENK K2 1231 KEINE NF AUSG TX                   12
0645 06165 BF AUT PT. 250KW LENK K1 1201 TX EIN                                    13
0645 06165 . MELD  . . . 1. . . .  LENK K1 1239 HS SCHALTER KWS 1                  14
0645 06165 . MELD  . . . 1. . . .  LENK K1 1322 FREQUENZSPEICHER 2                 15
0646 06165 BEFEHL AUSGEFRT LENK K1 2402 BETRIEB F2   6.165 MHZ                   16
0646 06165 . MELD  . . . 1. . . .  LENK K1 1221 TX STANDBY                         17
0646 06165 . MELD  . . . 1. . . .  LENK K1 1223 TX P 250KW                         18
0646 06165 BF AUT M WERT   LENK K1 1571 TRAEGERLEIST.   (KW)      261.05         19
0647 06165 BF AUT M WERT   LENK K1 1570 FREQUENZ  (HZ)          06165000         20
0651 03985 . DRAL  . . . 0. . . .  LENK K2 1231 KEINE NF AUSG TX                   21
0706 06165 BF ZT   M WERT  LENK K1 1571 TRAEGERLEIST.   (KW)      263.35         22
0707 03985 BF ZT   M WERT  LENK K2 1571 TRAEGERLEIST.   (KW)      267.95         23
0829 06165 . NDAL  . . . 1. . . .  LENK K1 2222 WASSER NACHFUELLEN                 24
0830 06165 . NDAL  . . . 0. . . .  LENK K1 2222 WASSER NACHFUELLEN                 25
1016       * DRAL D2. . 1. . . .  LENK EV 1628 ZYLINDERTEMP. UNGLEICH            26
1017       . DRAL D2. . 0. . . .  LENK EV 1633 MIN PEGEL SCHMIEROEL              27
1022       . DRAL D2. . 0. . . .  LENK EV 1628 ZYLINDERTEMP. UNGLEICH            28
1023       . MELD  . . . 0. . . .  LENK IF 1723 GEMEINDEWASSERVENTIL              29
1023       . MELD  . . . 1. . . .  LENK IF 1725 GEMEINDEWASSER >7ATUE             30
1023       . MELD  . . . 0. . . .  LENK IF 1727 HALLENBADVENTIL                   31
1034 03985 * DRAL  . . . 1. . . .  LENK K2 2225 DAMPFUEBERDRUCK                   32
1034 03985 . NDAL  . . . 1. . . .  LENK K2 2222 WASSER NACHFUELLEN                 33
1035 03985 . NDAL  . . . 0. . . .  LENK K2 2222 WASSER NACHFUELLEN                 34
1039       * DRAL D2. . 1. . . .  LENK EV 1827 MAX PEGEL SCHMIEROEL               35
1040       . MELD  . . . 1. . . .  LENK IF 1723 GEMEINDEWASSERVENTIL               36
1040       . MELD  . . . 0. . . .  LENK IF 1725 GEMEINDEWASSER >7ATUE              37
1040       . MELD  . . . 1. . . .  LENK IF 1727 HALLENBADVENTIL                    38
```

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



```
PR SARNKO 15
1224 09535 ..... ........ SARN KO 1500 HF MESSWERTE
1224 09535 M WERT B0-B1 B1 SARN KO 1551 FREQUENZ  (HZ)          09535000
1224 09535 ..... B0-B2 B2 SARN KO 1552 TRAEGERLEIST.  (KW)       253.20
1224 09535 . MELD B0 B0    SARN KO 1553 VSWR  (1)+1               0.07
1224 09535 M WERT ........ SARN KO 1554 IC  H1  (A)               1.44
1224 09535 M WERT ........ SARN KO 1555 IC  H2  (A)              27.84
1224 09535 ..... ........ SARN KO 1560 NF MESSWERTE
1225 09535 M WERT ........ SARN KO 1561 IC V3 N1  (A)             3.12
1225 09535 M WERT ........ SARN KO 1562 IC V4 N1  (A)             4.00
1225 09535 M WERT ........ SARN KO 1563 UA HS GR  (KV)           13.68
1225 09535 M WERT ........ SARN KO 1564 KUEHLUNG H20  (GRAD C)   38.50
```

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



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PR LENKEV 14
1341        ..... ........ LENK EV 1400 MESSWERTE STARKSTROM
1341        M WERT ........ LENK EV 1451 SAMMELSCHIENE 16KV R      14.07
1341        M WERT ........ LENK EV 1452 SAMMELSCHIENE 16KV S      14.00
1341        M WERT ........ LENK EV 1453 SAMMELSCHIENE 16KV T      14.14
1341        M WERT ........ LENK EV 1454 WIRKLEISTUNG NETZ (KW)  1148.07
1341        M WERT ........ LENK EV 1455 COSINUS (16KV SEITE)      0.66
1341        M WERT ........ LENK EV 1456 WIRKLEISTUNG HILFSBETR   49.92
```

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

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.

36 Situation printout

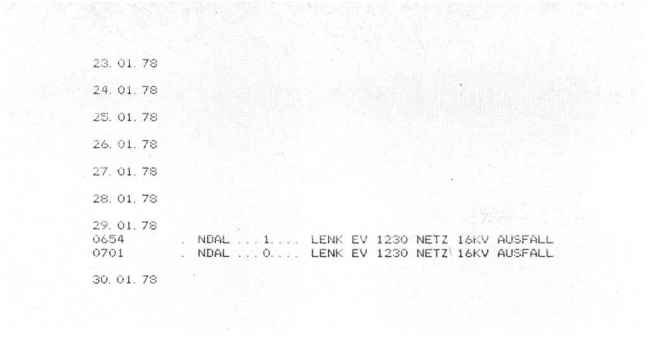
Situation printouts are composed of preselected data records of different files and process areas.

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)

1	High tariff meters switched on by Regional Power Station mains command
2	Processor gave instruction to transmitter 2 for operation at carrier power of 250 kW and frequency of 3.985 MHz
3	Transmitter connected to 16 kV high voltage
4	Frequency store with frequency of 3.985 MHz connected
5	Monitoring criterion of transmitter 2 has been actuated
6	Acknowledgement that the transmitter is tuned to the correct frequency
7	The transmitter assumed the STANDBY position
8	The transmitter assumed the OPERATION position at 250 kW
9	Monitoring criterion of transmitter 2 reset
10	Automatic power check after switching-on sequence
11	Automatic frequency check after switching-on sequence
12	Resetting of modulation control
13...21	Switching-on sequence of transmitter 1 for operation at a power of 250 kW and a frequency of 6.165 MHz
22 and 23	Printout of carrier power of both transmitters for statistical purposes
24 and 25	The boiling/cooling system of transmitter 1 has topped up with cooling water
26	The 1000 kVA diesel installation 2 is faulty; the cylinder loading is not uniform
27 and 28	The installation alarms have been reset
29 and 30	The drawing of water from the communal reservoir has been prohibited because of a fall in pressure
31	The warm water from the transmitter cooling system is no longer being routed to the heating system of the indoor swimming pool at Lenk
32	The boiling/cooling system of transmitter 2 has been overloaded
33 and 34	See 24 and 25
35	The upper level of the lubricating oil of the 1000 kVA diesel installation 2 has been exceeded
36...38	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 indoor swimming pool



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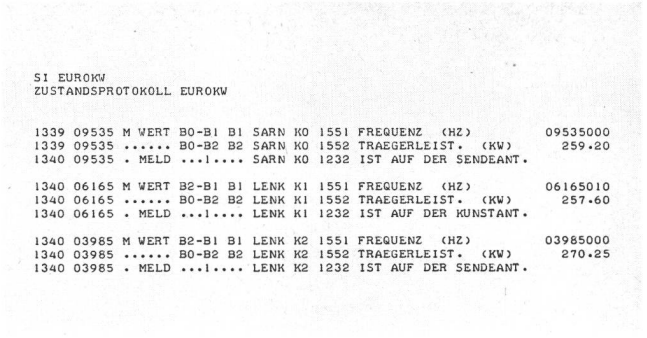
23. 01. 78
24. 01. 78
25. 01. 78
26. 01. 78
27. 01. 78
28. 01. 78
29. 01. 78
0654        . NDAL ...1.... LENK EV 1230 NETZ 16KV AUSFALL
0701        . NDAL ...0.... LENK EV 1230 NETZ 16KV AUSFALL
30. 01. 78
```

Fig. 10
Extract from a situation printout



```
SI EUROKW
ZUSTANDSPROTOKOLL EUROKW

1339 09535 M WERT B0-B1 B1 SARN K0 1551 FREQUENZ  (HZ)          09535000
1339 09535 ..... B0-B2 B2 SARN K0 1552 TRAEGERLEIST.  (KW)       259.20
1340 09535 . MELD ...1.... SARN K0 1232 IST AUF DER SENDEANT.

1340 06165 M WERT B2-B1 B1 LENK K1 1551 FREQUENZ  (HZ)          06165010
1340 06165 ..... B0-B2 B2 LENK K1 1552 TRAEGERLEIST.  (KW)       257.60
1340 06165 . MELD ...1.... LENK K1 1232 IST AUF DER KUNSTANT.

1340 03985 M WERT B2-B1 B1 LENK K2 1551 FREQUENZ  (HZ)          03985000
1340 03985 ..... B0-B2 B2 LENK K2 1552 TRAEGERLEIST.  (KW)       270.25
1340 03985 . MELD ...1.... LENK K2 1232 IST AUF DER SENDEANT.
```

Fig. 11
Extract from a transmitter station 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.

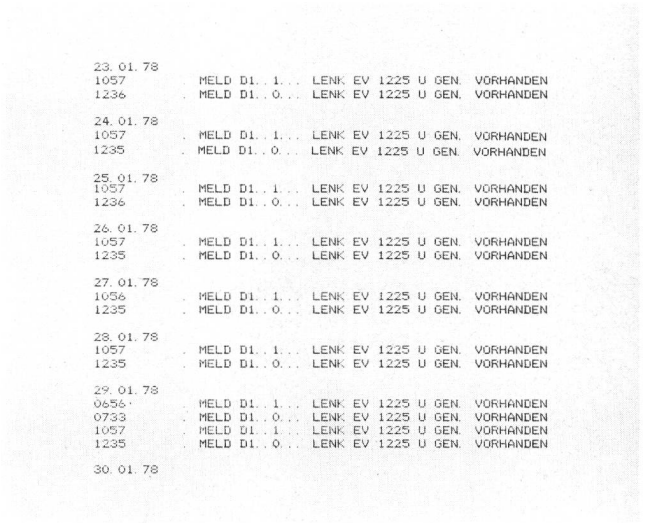
5 Concluding observations

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.



```
23. 01. 78
1057        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1236        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

24. 01. 78
1057        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1235        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

25. 01. 78
1057        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1236        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

26. 01. 78
1057        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1235        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

27. 01. 78
1056        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1235        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

28. 01. 78
1057        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1235        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

29. 01. 78
0656        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
0733        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN
1057        . MELD D1..1... LENK EV 1225 U GEN. VORHANDEN
1235        . MELD D1..0... LENK EV 1225 U GEN. VORHANDEN

30. 01. 78
```

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