Antenna Control System for EME

Jean-Jacques Maintoux, F1EHN
24, Rue de Villacoublay, F-78410 Velizy, France

This system allows manual or automatic tracking of various sources (moon, sun radio-sources). This system is primarily suited for EME operation. Moreover, it helps to manage traffic procedures in real time and to calibrate the station (measurements of received levels, tracking of radio-sources etc ...).

This system is divided into:

- An initialization module (call sign, location, serial port, endstop, track hysteresis ...) called by the control software.
- A control module capable of handling an EME station in real time (automatic tracking of sources, periods, doppler ...).
- Hardware interface between the control software and the EME station (motors, angles monitoring, receiver).

Specifications of pupitre.exe and init.exe files:

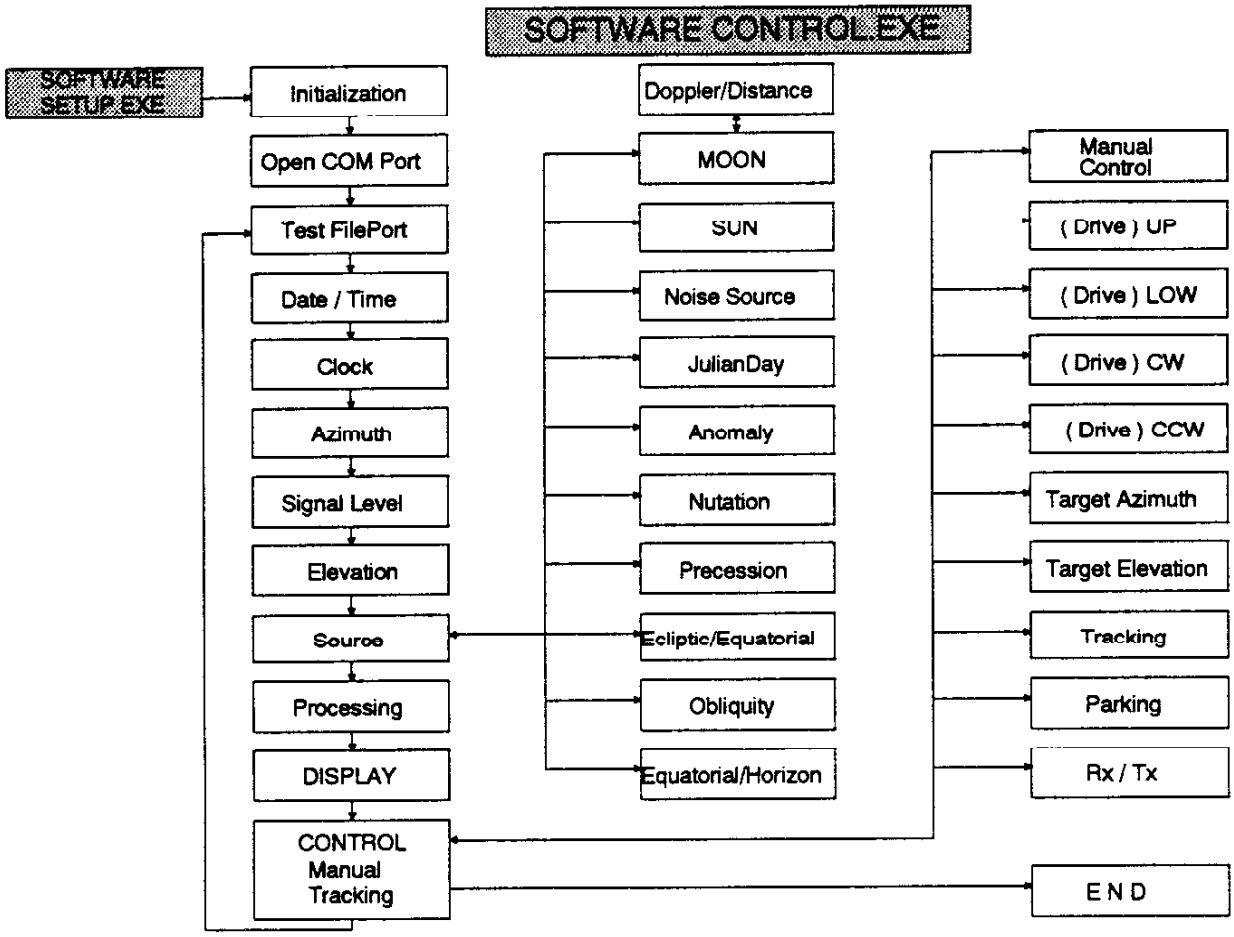
- These programs have been written in PowerBASIC. The delivered files are already compiled and directly executable on an IBM PC or compatible with a CGA monitor (or EGA, VGA) 256 KBytes of RAM and a RS232 port.
- The delivered files can make use of the math coprocessor on request. -The serial port can use COM1 to COM4.
- The PC clock is set to GMT or local time.
- This new version is English written.

Interface specification:

- A specialised circuit is used hoocked to serial port of the PC.
- The azimuth entries (0 to 359.99 degrees) and elevation entries (0 to 359.99 degrees) are coded with 16 bits (parallel) allowing a fine step of 0.0055 degree.
- Inputs are TTL compatible (enabled on high level).
- The received signal strength is coded with 8 bits (parallel). Inputs are TTL compatible (enabled on high level) : 0=0 dB, 255=51 dB (Resolution is 0.2 dB per Bit).
- 4 relays are used to drive azimuth and elevation motors (up, down, right, left).

Angular resolution of the system:

- The resolution depends on the number of bits used by the interface. The non-used bits are grounded. The software internally uses the maximum resolution of 16 bits to perform calculations but the display limits the final resolution to 0.1 degree.

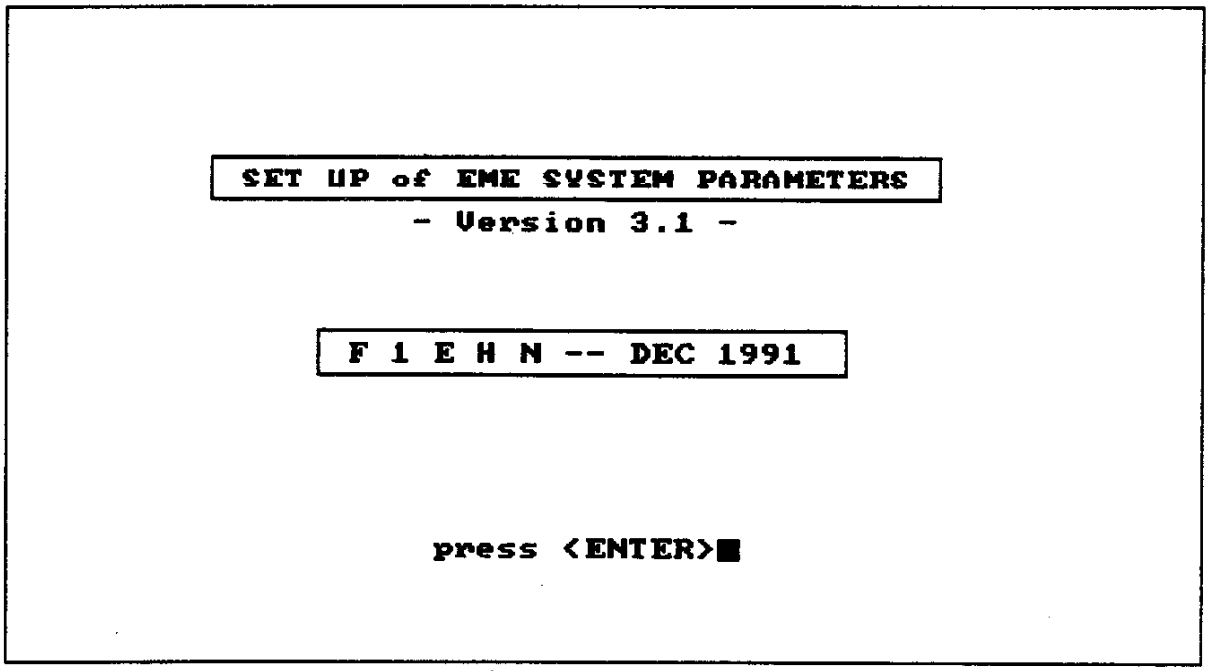


Bild/Figure 1: Module-Diagram of CONTROL.EXE

- The angular resolution also depends on the rotation speed of the motors (for example 0.2 deg/sec) and on computation time of the PC (for example 80286 @ 8 MHz = 0.3 sec). In this example the resolution is: 0.2*0.3 = 0.06 degree.

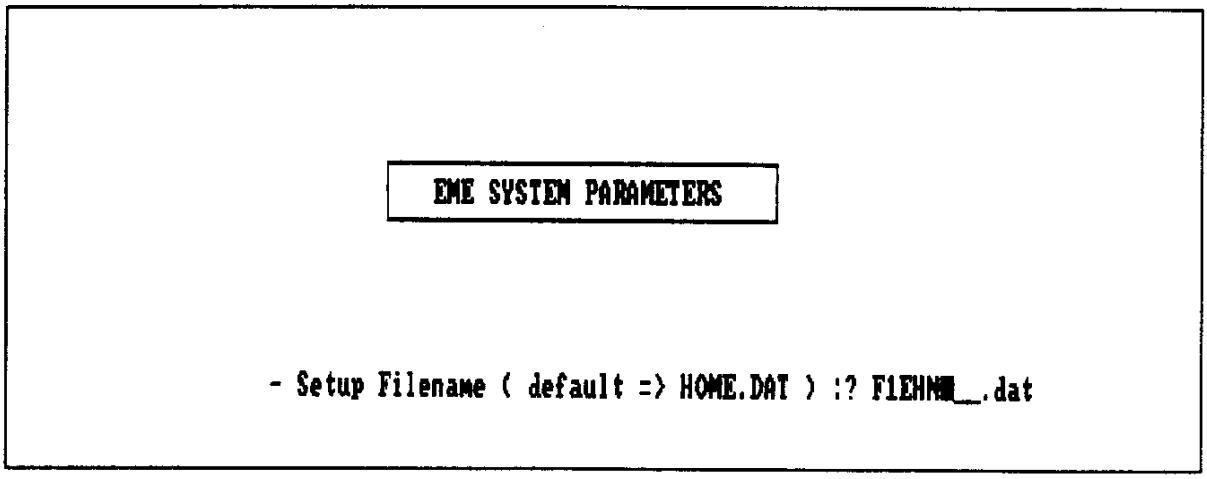
INITIALISATION MODULE SETUP.EXE:

Introduction menu and version number of setup.exe:



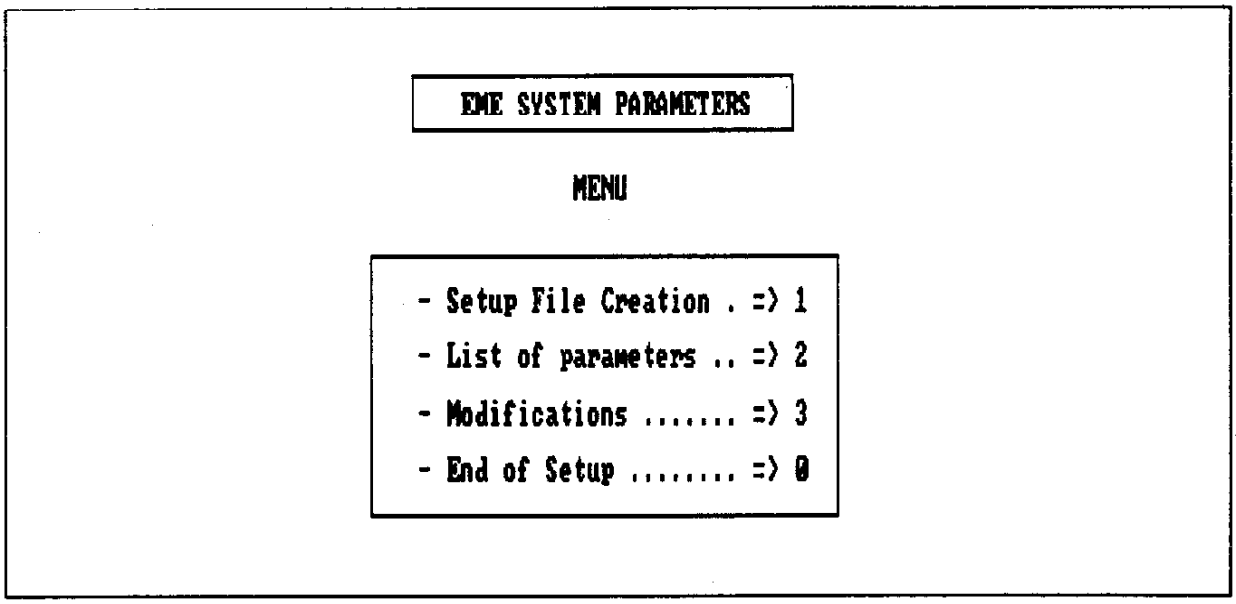
Bild/Figure 2: Introduction Menu

All parameters are stored in a .dat file. It is possible to give several names in order to store several configurations (expeditions, stations ....):



Bild/Figure 3: Define Setup-File Name

A menu allows to create, read or alter a file:

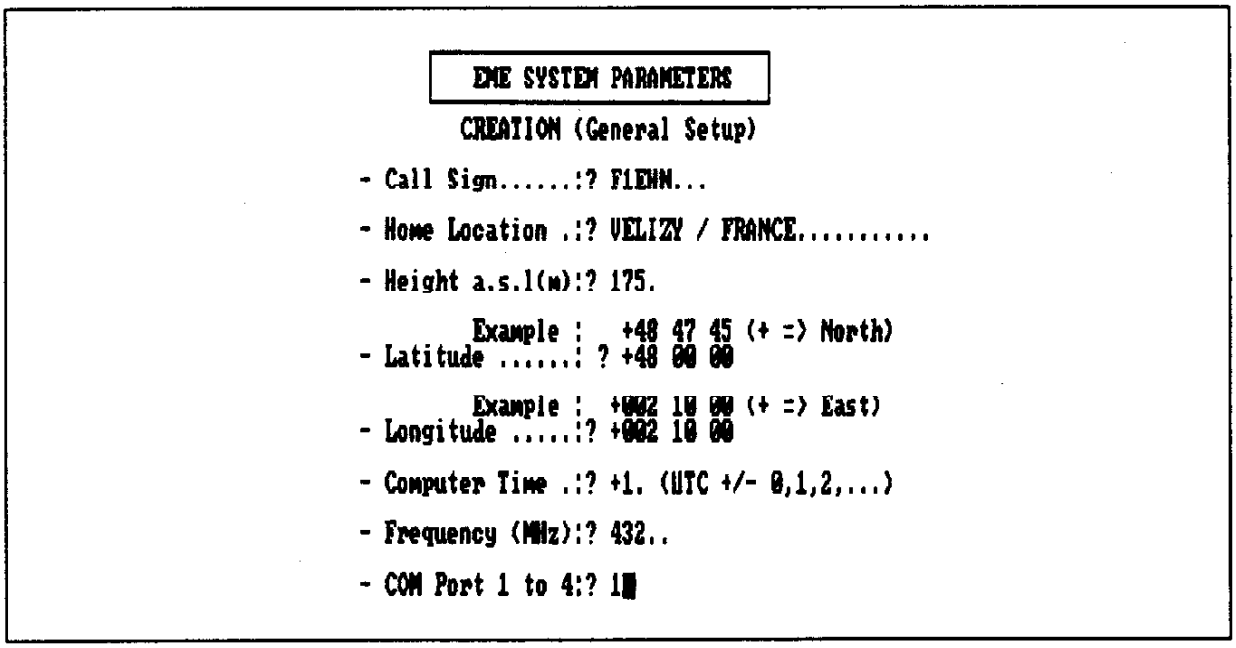


Bild/Figure 4: Setup-File Commands

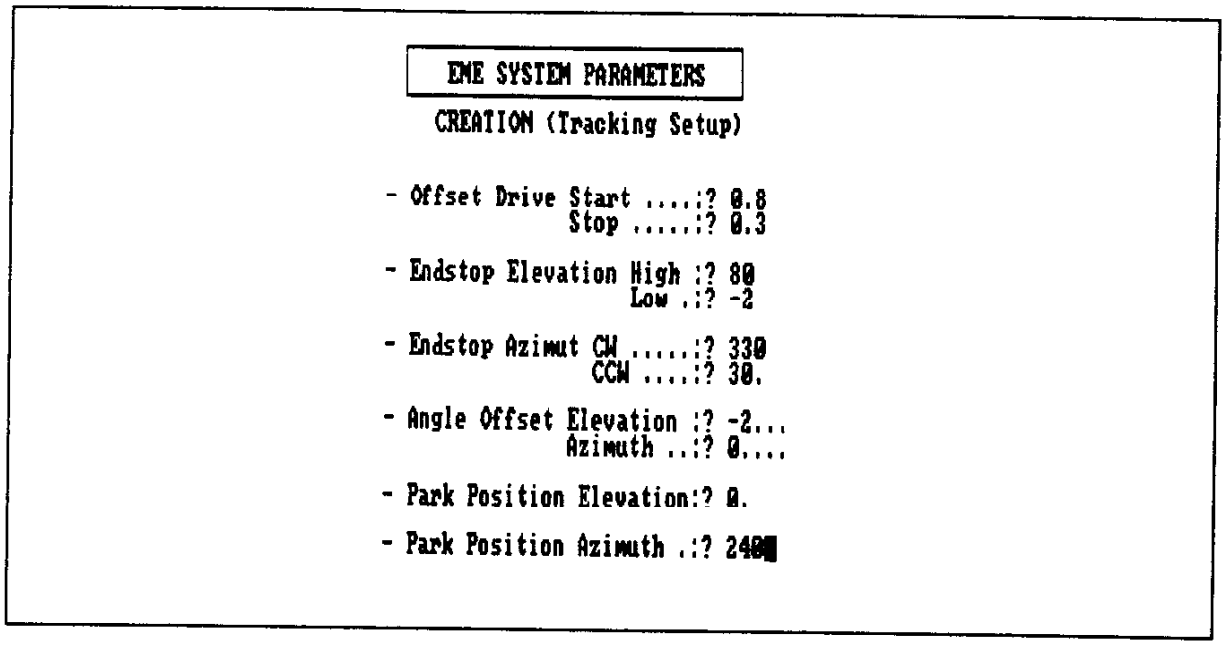
Call sign (8 characters max), location (26 characters max) etc ... are entered while creating a new .dat file.

Track Hysteresis:

1. **Offset Drive Start :** The drive (or Motor) starts when the angle offset between antenna and target is greater than this value.
2. **Offset Drive Stop :** The drive (or Motor) stops when the angle offset between antenna and target is smaller than this value.



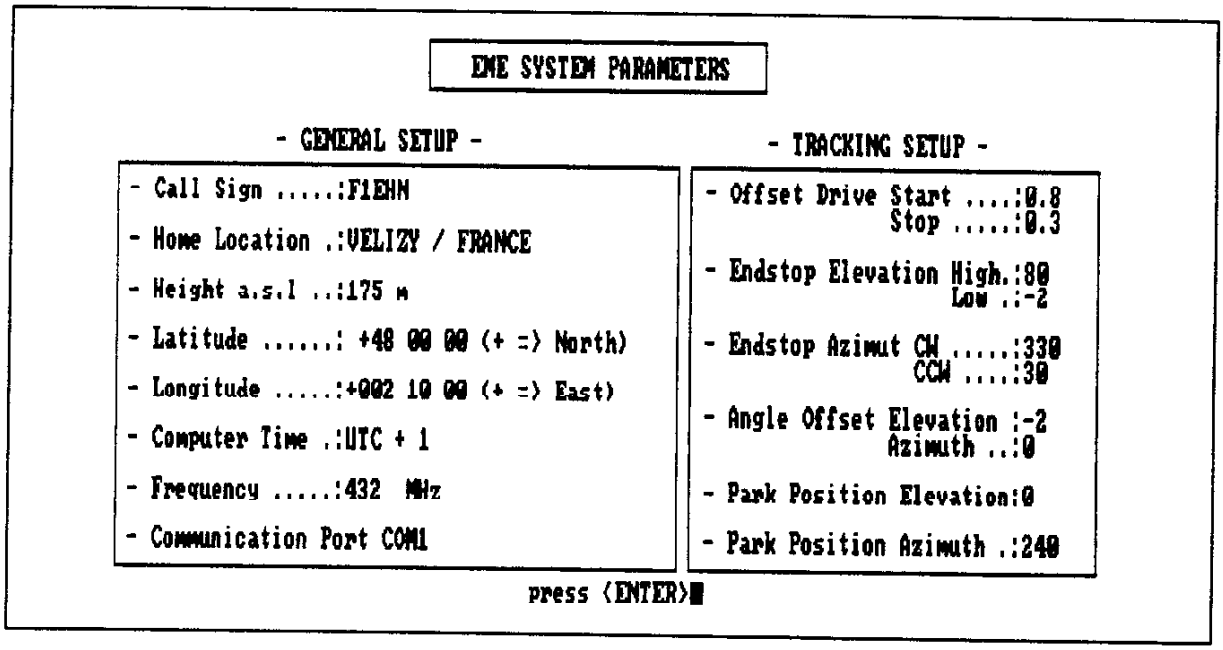
Bild/Figure 5: System Parameters (General Setup)



Bild/Figure 6: System Parameter (Tracking Setup)

3. **Endstop:**
   Azimuth: CCW -> Rotat e Counterclockwise
   Elevation: Low -> Rotate Down
   High -> Rotate UP
   The Drive (and AUTOTRACK of course) stop when the angle between and endstop is equal zero
4. **Angle Offset:** is the value of the elevation (azimuth) when the interface input is set to zero
5. **Park Position:**is the value of the elevation (azimuth) of the park position of the antenna

Each parameter can be displayed and modified:



Bild/Figure 7: Display Setup Parameter

```
                    EME SYSTEM PARAMETERS

                       MODIFICATIONS

                  - General Setup ....: 1
                  - Tracking Setup ...: 2
                  - If no change .....: 0
```

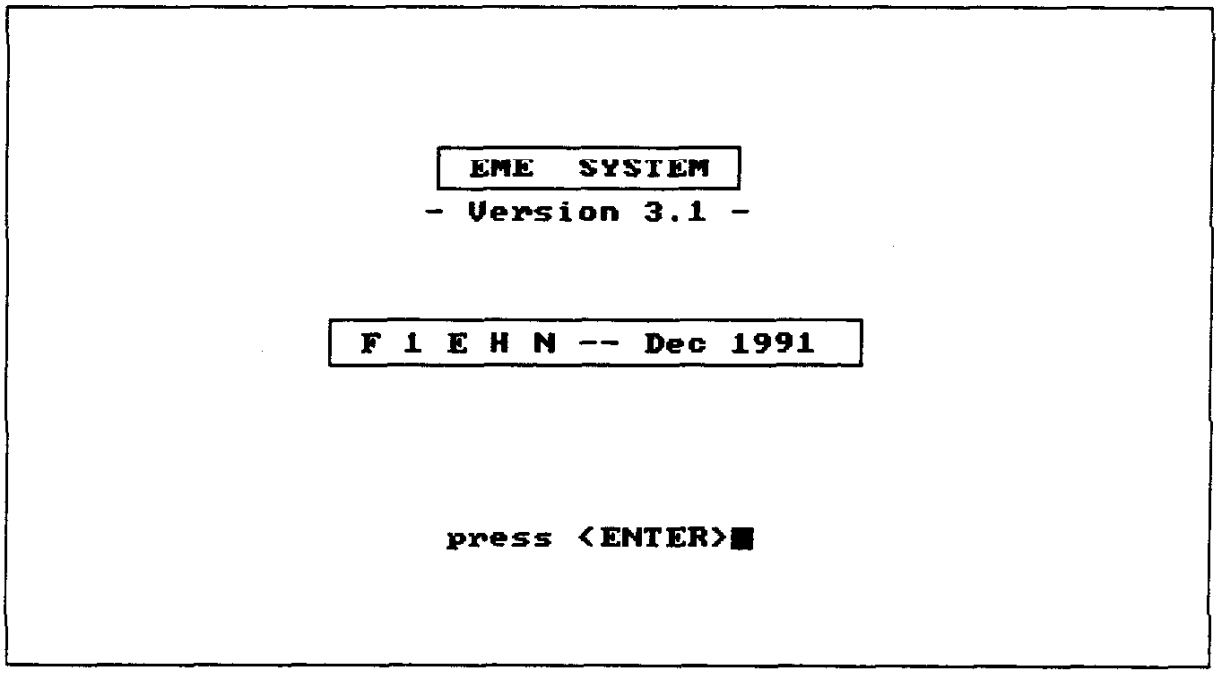
```
                    EME SYSTEM PARAMETERS

     MODIFICATIONS ( General Setup ) ; if no change , press <ENTER>

- Call Sign .....:F6KSX                      ? F1EHN...
- Home Location .:VELIZY / FRANCE            ? VELIZY / FRANCE
- Height a.s.l ..:175 m                      ? 175
        Example : +48 47 45 (+ => North)
- Latitude ......: +48 00 00                 ? +48 02 00
        Example :+002 10 00 (+ => East)
- Longitude .....:+002 10 00                 ? +002 10 00
- Computer Time .:+1   (UTC) +/- 0,1,2,....: ? +1.
- Frequency .....:432  MHz                   ? 144..
- Communication .:Port COM1                  ? 1
```

```
                    EME SYSTEM PARAMETERS

     MODIFICATIONS ( Tracking Setup ) ; if no change , press <ENTER>

- Offset Drive Start ....:0.8               ? 0.8
                  Stop .....:0.3            ? 0.4

- Endstop Elevation High :80                ? 80
                     Low .:-2               ? -2

- Endstop Azimut CW .....:330               ? 300
                  CCW ....:30               ? 60.

- Angle Offset Elevation :-2                ? -2
                  Azimuth ..:0              ? 0

- Park Position Elevation:0                 ? 0

- Park Position Azimuth ..:240              ? 240
```

Bild/Figure 8: Screens for System-Parameter

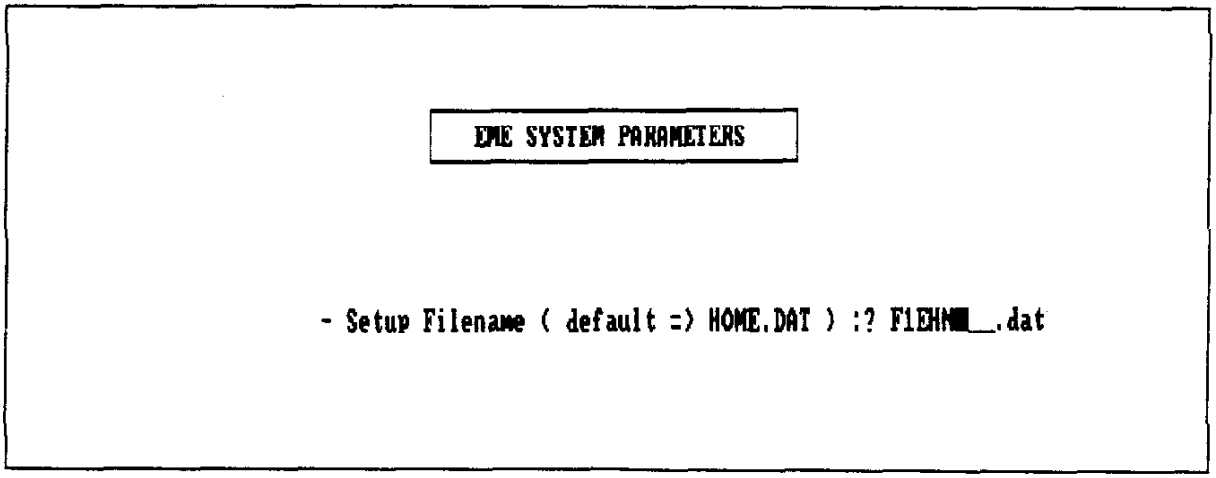
CONTROL SOFTWARE CONTROL.EXE:

This module only works if it is connected to a RS232 interface. Introduction menu and version number of CONTROL.EXE:



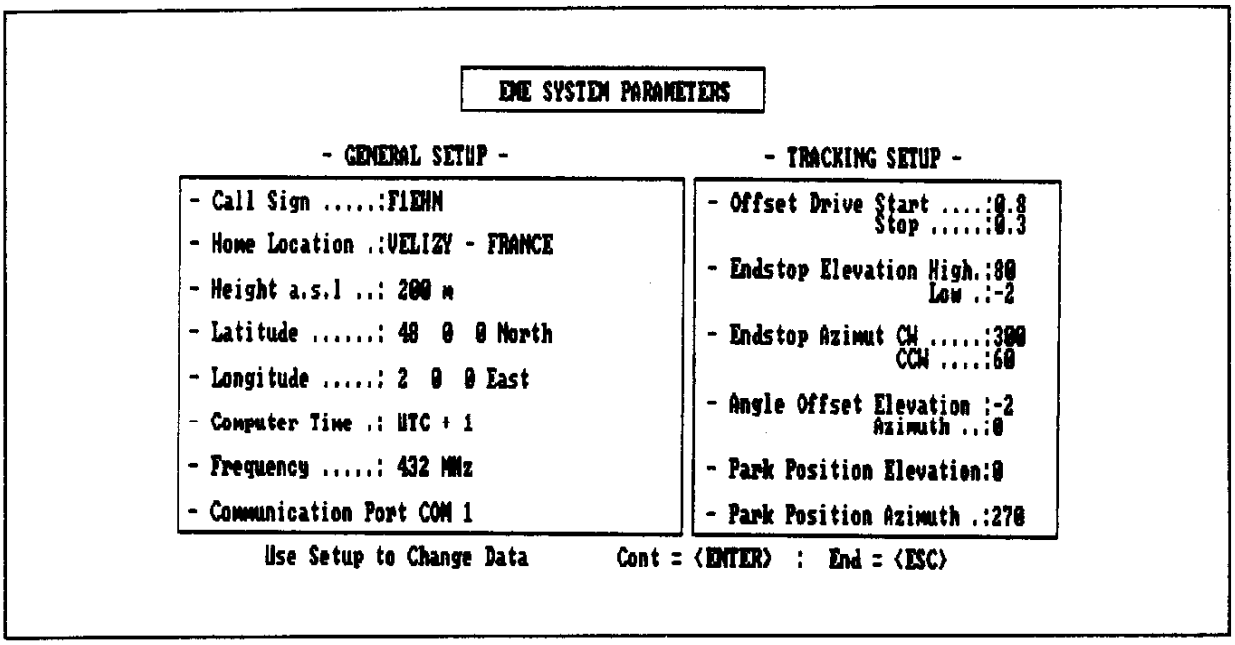
Bild/Figure 9: Introduction Menu

Selected .dat file (for initialisation):



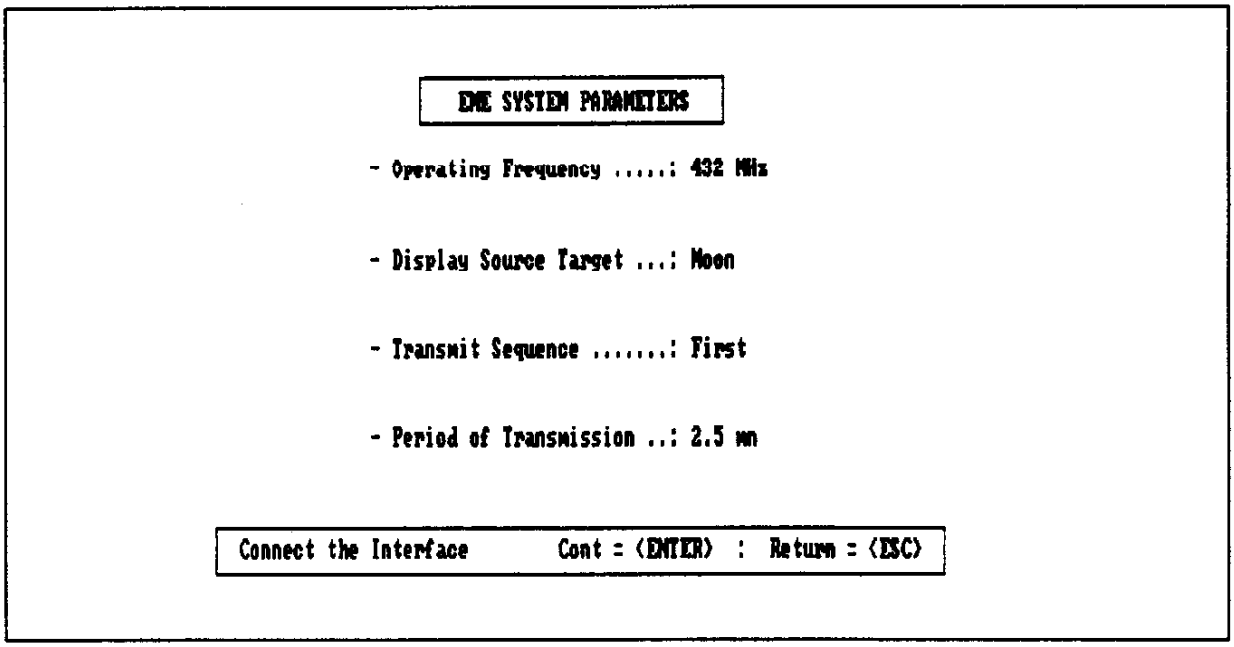
Bild/Figure 10: Select Setup-Parameter File

Selected .dat file read into memory. Display of parameters stored in SETUP.EXE:



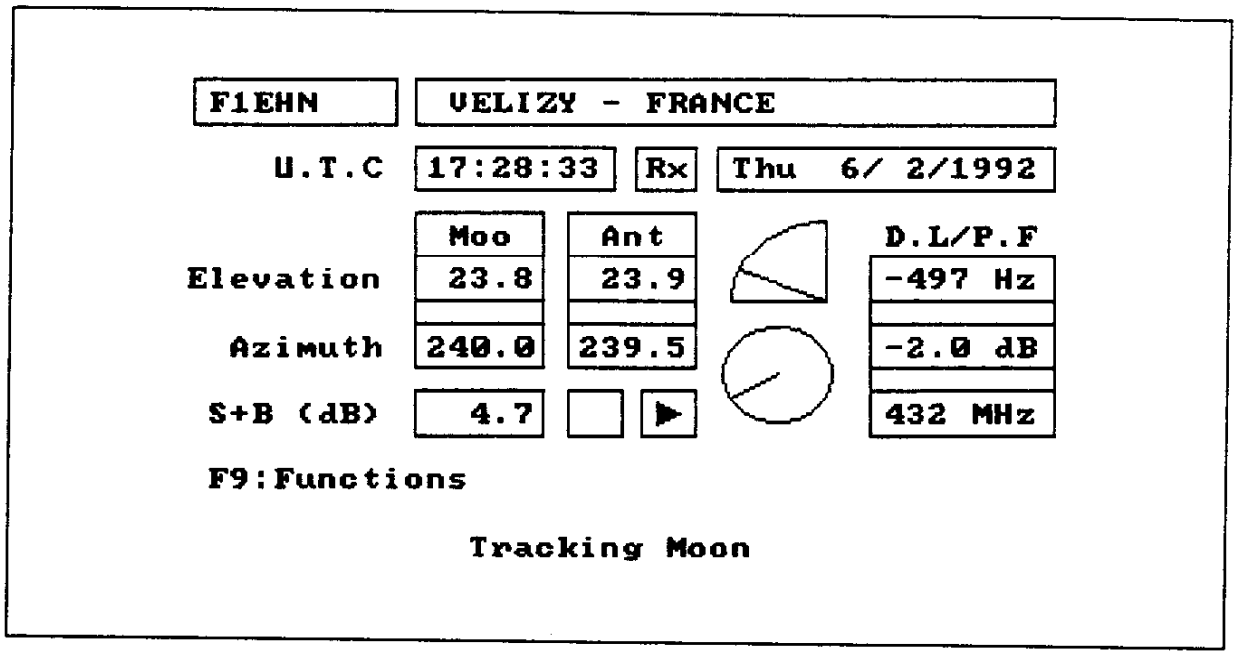
Bild/Figure 11: Show setup-Parameters

Choice of traffic parameters:



Bild/Figure 12: Operating Parameters

AUTOMATIC TRACKING OF THE MOON:

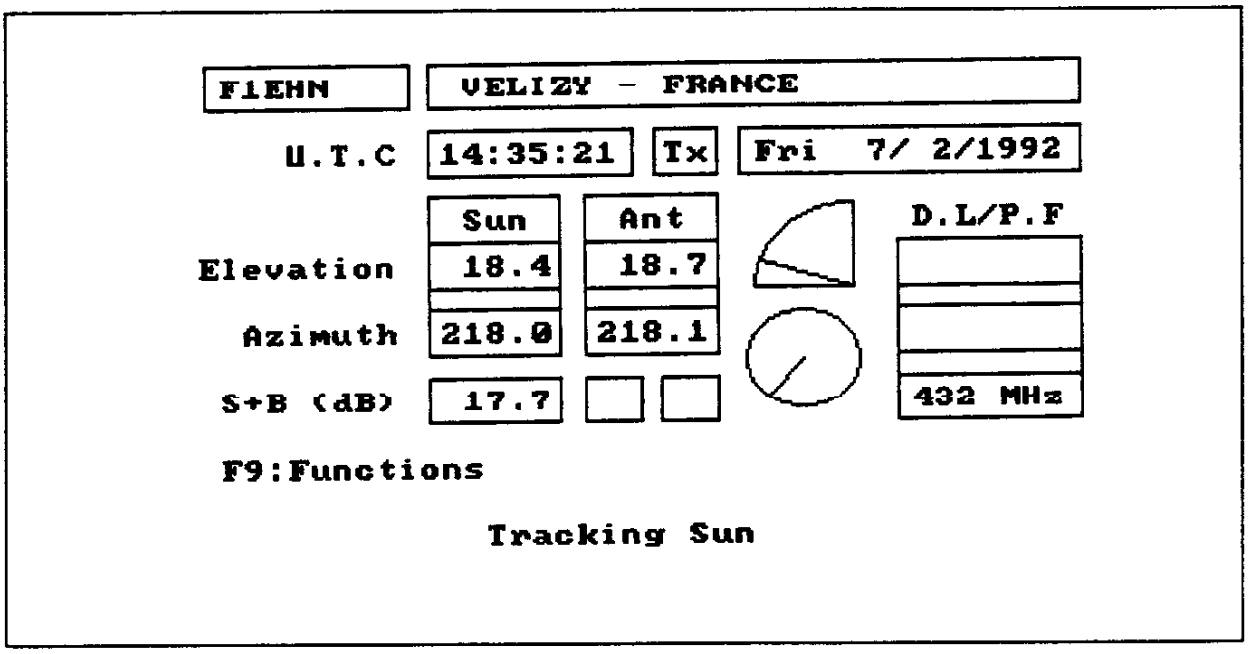


Bild/Figure 13: Tracking Window

The software displays in real time several parameters:

- Time and date (U.T.C) - Location of moon (az and el).
- Period of traffic (RX,TX). A beep indicates a new period.
- Received signal strength.
- Rotation direction of antennas.
- Doppler frequency shift (caused by earth rotation and moon/earth speed). -
- Extra loss (Loss/Perigee) due the actual distance between moon and earth.
- Fixed parameters (call-sign, location, frequency).
- Control keys:
  - F1 = Az : Azimuth of target
  - F2 = El : Elevation of target
  - F3 = Auto/M : Automatic or Manuel tracking
  - F4 = Source : Choice of source
  - F5 = NormL : Normal Level Measurement (Reset F8)
  - F6 = PeakL : Peak Level Measurement (Reset previous peak value)
  - F7 = AverL : Average Level Measurement (20 values)
  - F8 = ResetL : Reset Level (Offset Measurement)
  - F9 = Foff : Enable or Disable Functions Menu
  - F10= Quit : Quit the program and park the antenna
  - Cursors : Manual commands.

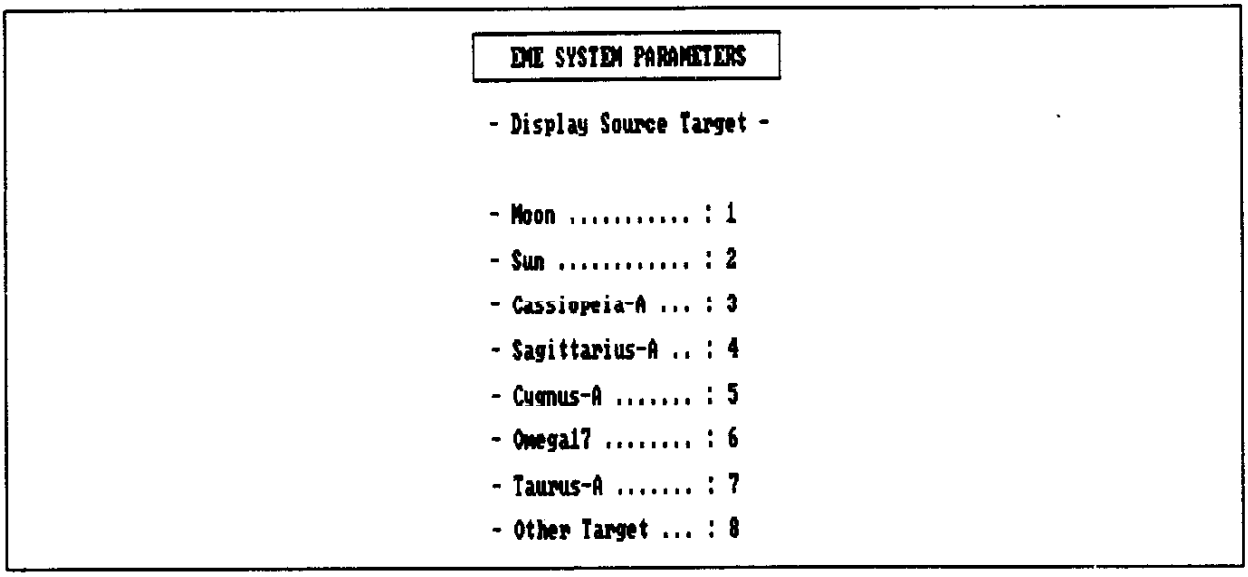
MEASUREMENTS WITH NOISE SOURCES (Ex : SUN):



Bild/Figure 14: Sun Tracking

The received signal strength allows the user (in manual mode) to draw the antenna radiation pattern (db/degree). It is then necessary to use a logarithmic detector or measure a voltage from a linearised AGC (V/dB).

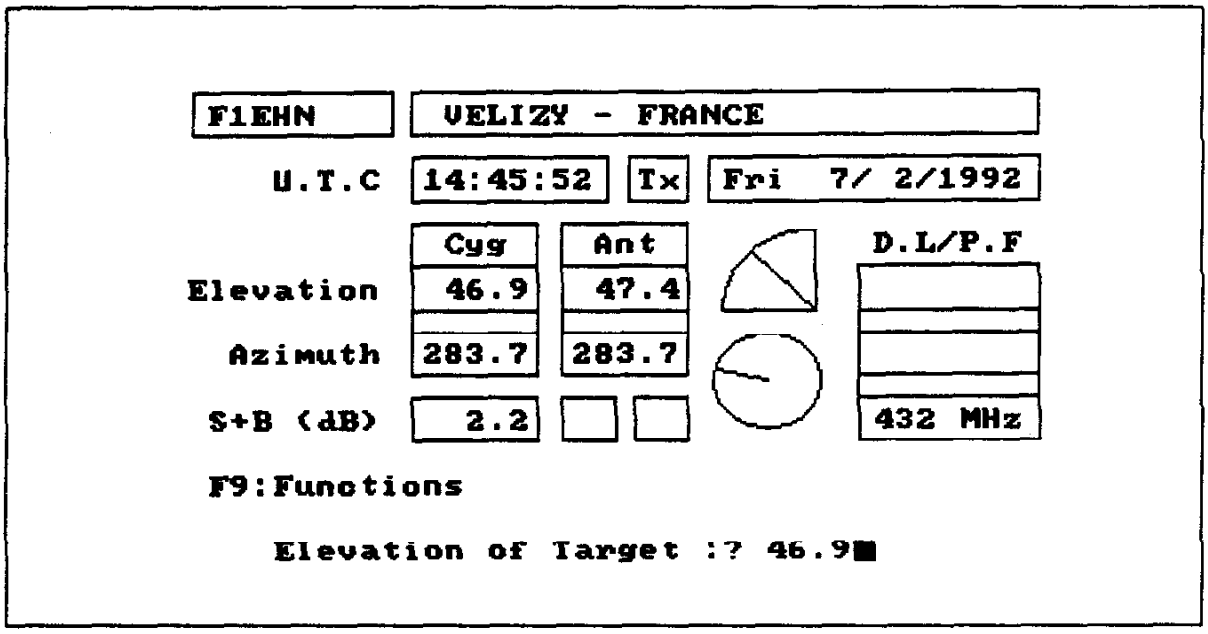
In tracking mode it is possible to get a feel for the quality of the actual tracking by recording the variations of the received signal level.



Bild/Figure 15: Noise Source Selection Menu

The tracking of a radio-source allows the checking of an EME station by looking at the difference in level between a noise source (ex: OMEGA17) and a "cold or quiet" source (ex: PICTOR). More details are given under YFACTOR part in the VK3UM EME planner. A source a selected with F4 is shown in Figure 15.

Azimuth or Elevation of target (F1 or F2):



Bild/Figure 16: Noise Source Coordinates Input

RESULTS:

The observatory of Paris (Bureau des longitudes) gave me accurate coordinates of the moon and the sun for a given time and date:

	Observatory	**F1EHN**
Sun	234.88/28.81	234.7/28.9
Sun	248.35/20.14	248.2/20.2
Moon	86.86/21.59	86.7/21.4
Moon	98.12/30.95	97.9/30.8

The obtained results are very satisfactory. Calculation routines are described in : "Astronomy with your personal computer" by Peter DUFFET-SMITH.

INTERFACE SOFTWARE/ANTENNA:

DIAGRAM: See appendix.

TIME-DIAGRAM: See appendix.

DESCRIPTION:

The electrical schematic diagram is to be found in annexe. The interface is built around a specialised circuit for asynchronous protocols like RS232 (UART HD-6402 from MHS). Other components may of course be used instead. The parameters of the port are set by CONTROL.EXE to : 9600 Bauds, 8 bits, 1 stop bit, no parity.

Received messages are decoded by 2 PROMs type 63S281. The "Control" PROM interfaces the motors and a free channel for future use. The "Enable" PROM takes care of the RS232 BUS (TX mode) and reads datas on input ports.

- The received level byte is directly forwarded.
- The az and el channel (16 bits) is forwarded with 2 bytes.
- The accuracy of this interface is 0.0055 degree.
- The prototype has been wrapped
- The accuracy of the whole system depends mainly on the accuracy of the sensors and on the quality of the mecanical structure of antenna.

Examples of sensors:

1. Linear potentiometer (0.25% linearity) and 12 bit analog to digital converter.
2. 12 bit or more optical position sensor.
3. For "small" antenna arrays it is possible to use less accurate converter (8 bits for instance give 360/255=1.4 degree resolution in this case LSBs should be grounded).
4.

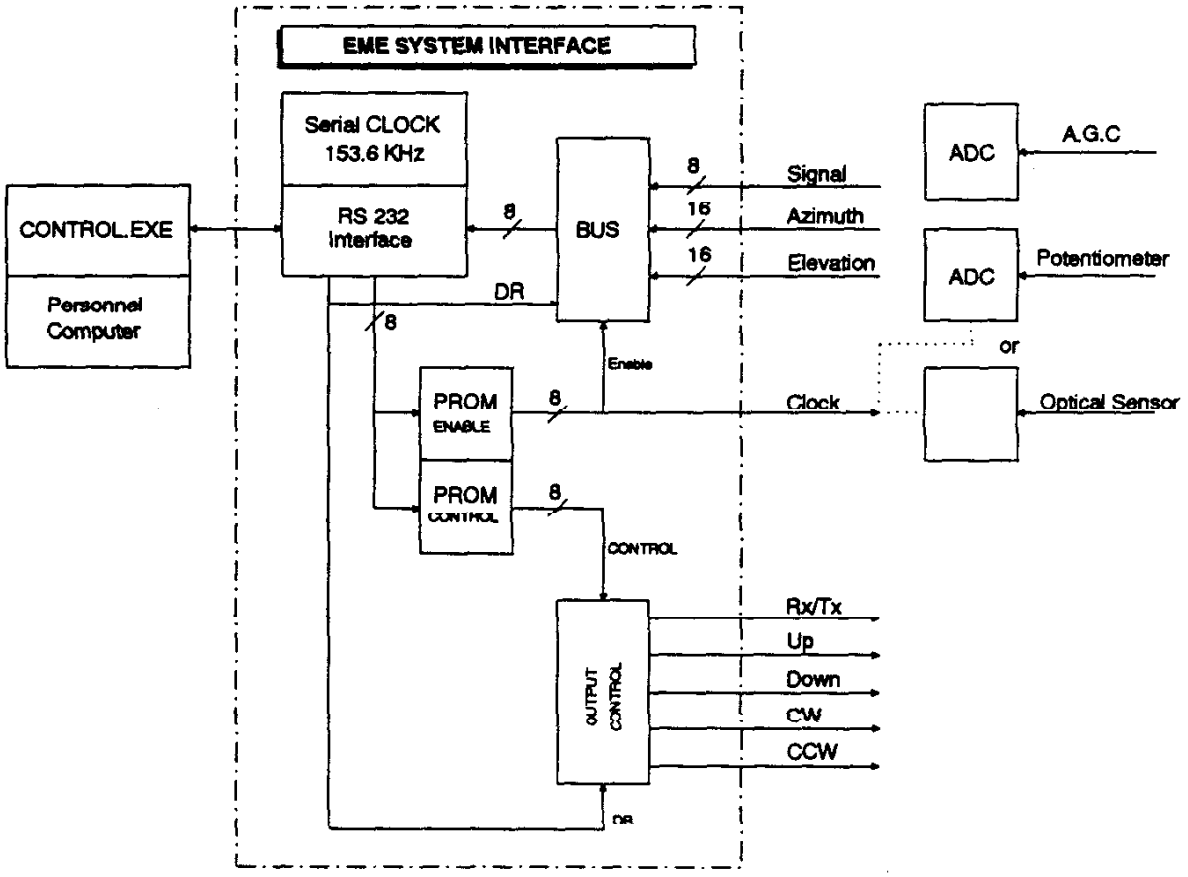
Several configurations are possible. F6KSX uses for its EME expeditions modified KR2000 and KR500B rotators (Potentiometers replaced by linear ones and rotation speed decreased) and 2 * 12 bit analog to digital converters (see schematic diagram in Appendix). The same converter is used for the signal channel.

CONCLUSION:

The system described allows easy and accurate , manual or automatic , control of antenna arrays. This great help frees the EME operator which in turn improves the efficiency of the EME station.

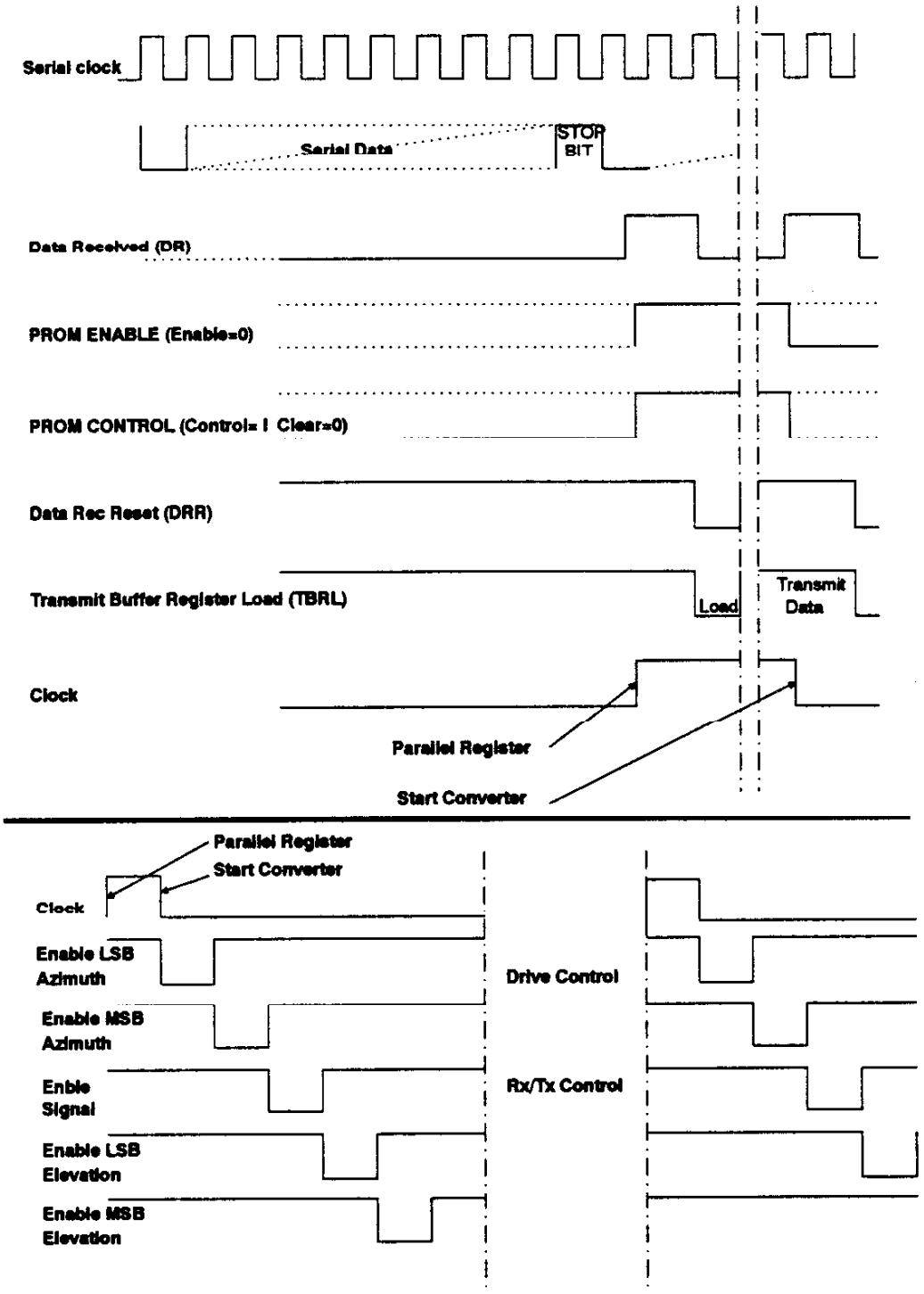
I shall be glad to help the interested OMs. CONTROL an SETUP software can be sent against a self-addressed and not formatted floppy. I can also program empty PROMs on request.

I wish to thank Herv F1HRY and the observatory of Paris for their help.



Bild/Figure 17: Diagram of System-Interface

TIME DIAGRAM

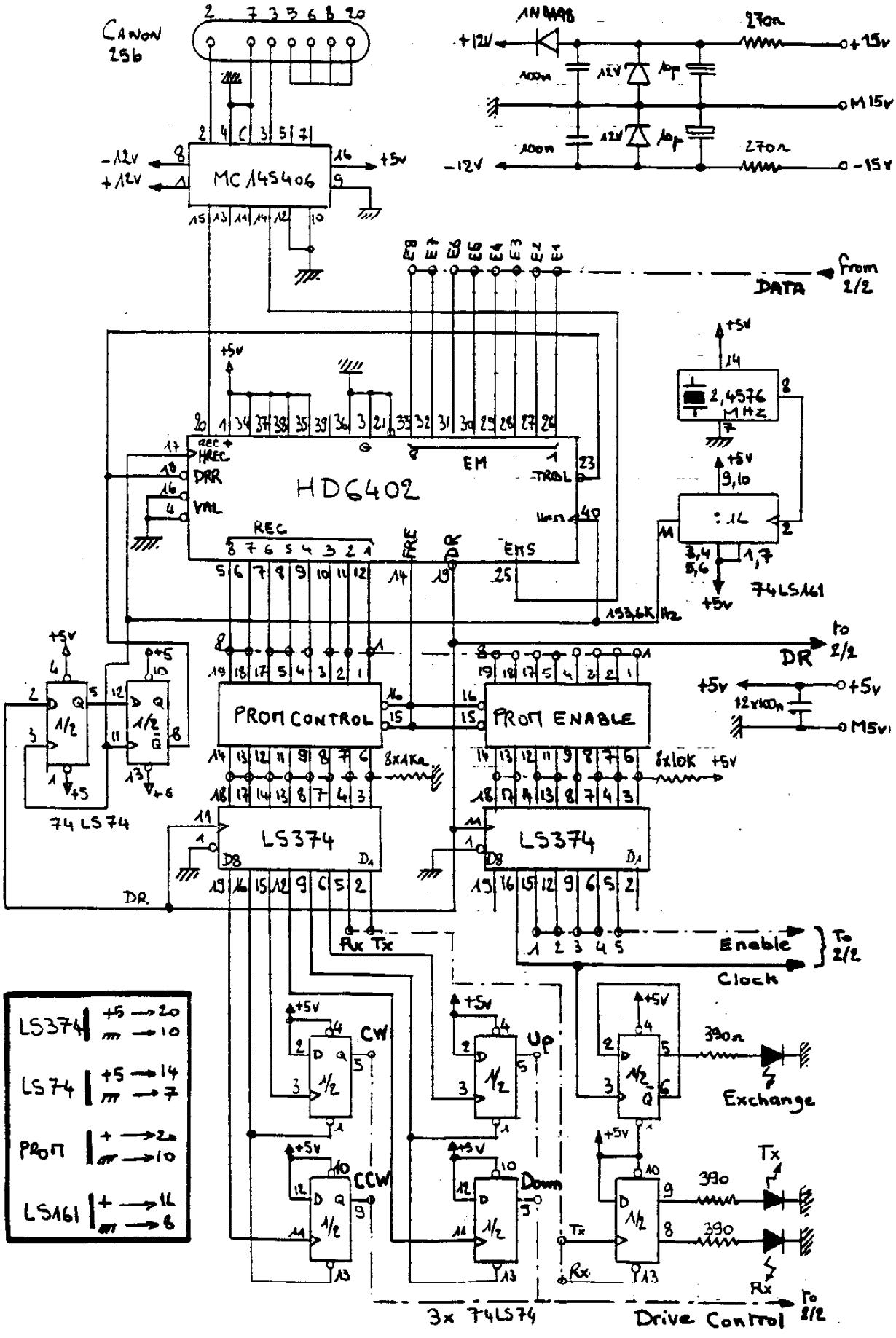


Bild/Figure 18: Timing-Diagram

PROM	Decimal Value	Work
Control	0	Stop Azimuth Drive
Control	1	CW (ClockWise)
Control	2	CCW (CounterClockWISE)
Control	3	Rx
Control	4	Tx
Control	16	Stop Elevation Drive
Control	17	Down
Control	18	Up
Enable	128	Azimuth Position (MSB)
Enable	149	Signal Received (0 à 51 dB)
Enable	150	Clock (A-D-Converter)
Enable	160	Azimuth Position (LSB)
Enable	192	Elevation Position (MSB)
Enable	224	Elevation Position (LSB)

The interface has free channels for future use or specific design .

Bild/Figure 19: Exchange PC/Interface


CANON 25b
MC 145406
-12V
+12V
+5V
-15V
+15V
DATA
From 2/2
HD6402
REC
DRR
VAL
EM
TRDL
EMS
2,4576 MHz
74LS161
153,6KHz
DR
To 2/2
PROM CONTROL
PROM ENABLE
74 LS 74
LS374
Rx Tx
Enable
Clock
CW
CCW
Up
Down
Exchange
Tx
Rx
3x 74LS74
Drive Control
LS374 +5 → 20 m → 10
LS74 +5 → 14 m → 7
PROM + → 24 m → 12
LS161 + → 16 m → 8

Bild/Figure 21: Circuit Diagram Part II