EME SYSTEM V7

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Annexes	Title - Subject	Annexes	Title - Subject
1	EME System - synoptic	11	16 bits // option - Schematic
2	Launcher	12	16 bits data // input
3	EME Setup (3)	13	Speed control option - Schematic
4	Angular configuration	14	PCB (photo) - Wiring
5	Tracking (3)	15	Components list
6	Planner (2)	16	ICP programming adaptor
7	DXCC Editor	17	P1 & RS232 Connectors
8	EME Calculator	18	Time diagram
9	Main function (2) - Schematic	19	VE1ALQ 16bits encoder
10	RS 485 Option - Schematic		

1   INTRODUCTION

EME System is a 32-bit application running under MS Windows (from 95 to VISTA version).

This system is primarily suited for EME operation. It helps to:

- Track the moon or any selected radio source or DSN objects with
    - A high accurate (16-bit) Azimuth/Elevation display (runs also without the interface)
    - A complete real time dialogue with the hardware interface to point your antenna toward the moon or the selected source with the same accuracy
    - Supporting a great number of existing interfaces and protocols.

- Manage the traffic procedures in real time with
    - The DXCC Common window world map including the moon footprint, the spatial polarization offset, a complete DXCC database,
    - The traffic management including the Doppler shift calculation, the RX/Tx corrected frequencies and RIG dialogue, the elapsed time during the Rx/Tx sequence, a text grid to memorize your traffic information (Date, time, freq, call sign, report…)
    - The brightness sky map with the sky temperature at the working frequency, the location of the different radio source (hot and cold), the antenna beam to the sky, your own radio electrical horizon and some astronomical information about the moon (range, hour angle, declination)

- Calibrate the station with
    - The measurements of received levels
    - The 2 axes antenna diagram measurement with an automatic scanning
    - The tracking of radio-sources
    - The complete calculations for an EME budget or noise measurement
    - The 2 axes angular corrections

- Plan the EME activity to prepare your skeds or traffic periods

EME System is divided into:

- A new front-end module (launcher) to manage EME System and launch directly the other modules

- An initialization module (emesetup) to set the parameters (call sign, location, serial port, end-stops, angular measurement and correction, station parameters, frequency...) called by the control software.

- A control module (tracking) capable of handling an EME station in real time (Automatic tracking of sources, traffic periods, Doppler, polarization and Rx/Tx management, signal level and antenna diagram measurements, common window, sky temperature..).

- A module (planner) to plan the EME activity (Moon location, Common window, Doppler, sky temperature ....).

- A module to edit the prefix and countries DXCC database (dxccedit).

- A module to help the operator about EME calculation to evaluate the average performance of the EME station (emecalc)

- An optional hardware interface between the control software and the EME station (Motors, angles monitoring, receiver...).

2   WHAT IS NEW IN THE 7.0 VERSION

This new version includes the intermediary updates of EME System like V6.1 to V6.3. Some new features were asked by the EME System users and are:

- Support of the current interfaces via DDE or serial communication protocols. Below find a non-exhaustive list of the supported interfaces and protocols by the real time tracking module.

Supported interfaces and protocols	Remarks and comments
Green Heron (RT21)	Using GH tracker
ARS EA4TX	DDE dialog
Yeasu G5500	Using GS232 protocol
Alfa Spid rotator, F1TE, G6LVB …	Using GS232 protocol
F1TE, G6LVB …(or any GS232 compatible interfaces)	Using GS232 protocol
DL7AOT (or any EasyComm1 compatible interfaces)	Using EasyComm1 protocol
EGIS rotator system (via EPR103/203)	(see chapter 3.5)
Pro. Sis. Tel rotator system (via CBox D)	(see chapter 3.6)
F1EHN interface	(see chapter 3.7)
MK-EHN interface	(see chapter 3.7)
W2DRZ or F1EHN compatible interfaces	(see chapter 3.7)

- A dedicated window for antenna diagram measurement is available.

- Dialog with the Google Earth software to automatically visualize the common window (Earth viewed from the tracked source) or the DX station location using the DXCC database. Moreover, if the DX station has a photo of its antenna in the EME antenna photos database*, the photo of the DX station is then displayed into Google Earth.

- Add of an indicator (like LED) to inform the operator about the running of the tracking module.

- Improvement on the running of the RIG management

- Improvement of the Man to Machine Interface of the Interface window (available with a F1EHN compatible interface)

- Improvement of the ability to memorize more parameters of the screen (MMI) of the different modules.

- The correction module is now integrated into the EMESetup module (new tab)

- The angular correction and angular offset values are now available for all interfaces

- The tracking is now compatible with the main "Satellites" software via a DDE channel. It allows to use the EME antennas to track any satellites supported by the dedicated software.

- EME System stays 100% compatible with the existing EHN or MK-EHN interfaces.

- Recently (2017), Gary N8CQ developed a small board MABMPU to allow the use of low cost encoders from Megatron (MAB / ETS) via the RS485 interface (with the USD protocol).

3 CONSIDERATIONS ON AN AUTOMATIC TRACKING SYSTEM

3.1 Angular resolution:

Several automatic tracking software and their interfaces are available in the radio-amateur domain. Most of these systems are based on an 8-bit digital accuracy. The best position measurement possible with these systems is :

360 degrees / 2^8 = 1.41 degree, which is fine for 144 MHz antennas or small 432MHz arrays. With bigger systems, losses due to the pointing error would be tremendous (-3dB angle for 16 yagis 7*lambda is close to +/- 2 degrees).

EME System uses a 16-bit format for both the software and the hardware (interface).

The obtained resolution is then: 360 / 2^{16} = 0.0055 degree.

The error due to this system is therefore negligible compared with the overall error in the tracking system. The only limitation is due the transducers used to determine the antenna's position (High resolution potentiometer + 12-bit ADC, optical encoder...).

3.2 Angular accuracy:

The accuracy of the position measurement is limited by the backlash, the measurement resolution (above-mentioned), the station's calibration, mechanical and electronic drifts of the system, capabilities of the computer, calculation errors.

- Backlash: Often due to the reduction gear assembly of the elevation and azimuth motors. This backlash may cause a "pumping" on the antenna's position. The most important backlash exists between the antenna and the angular transducer. This backlash translates directly into a position error.

- Station's calibration: At first, angular transducers must be set in azimuth (0 and 360 degrees) and elevation (0-90 degrees with a vertical level). Then, the setting should be done into a well-known direction. The control software allows an accurate setting on sun noise. A setting on a moon signal (with large fluctuations) or with a compass (not accurate) is not correct. The measurement of sun noise is also fine for checking the station's sensitivity at times.

- Mechanical and electronic drifts: These drifts can be estimated by tracking the sun and by checking the maximum sun noise elevation and azimuth. This can be cured by software (see chapters 5 and 8). Generally speaking, these drifts are due to mechanical twisting, offset variations (thermal problems), transducer non-linearity, antenna bending out of shape with the tilting and bad verticality of the mast or tower. The inaccuracy in position is variable.

- Computer's capabilities and dialog latency: The elapsed time between two calculations of the moon's position is equivalent to the mechanical backlash in the reduction gear assembly. The error is then proportional to the speed of rotation. For example with a recent PC the approximate computation time is 0.07 second (this time is mainly due to the RS 232 dialog). If the rotation speed of the antennas is 3 degree/sec then the backlash due to the computer is 0.07*3=0.21 degree. This backlash may result in a "pumping" effect. The time of latency of the MK-EHN interface is optimized to reduce it at the minimum value (about 60 ms).

Remark: This "pumping" effect is mastered by the software (hysteresis parameters in the setup menu).

- Calculation's error: All calculations are performed in double precision mode. The automatic tracking works with the interface with 16 bit words. Only the resolution of display has been reduced (position of moon and sources). Computed positions of both moon and sun have been compared with those calculated by "Bureau des longitudes de l'Observatoire de Paris". No significant error has been noticed.

3.3 INSTALL AND RUN

- See the "readme" file included into the downloaded package to have the latest information.

- Unzip the downloaded file from the web site in a temporary directory.

- Run the "Setup.exe" program. Follow the instructions.

- The "Setup" program makes a new group "EME System" and creates an icon for the launch application (new user interface).

- To use EME System, start Launcher with clicking on his icon.

3.4 Information for the users of the previous version:

Save your own ".dat", ".tcv", "map.bmp" files. Then put these files in the EME System current directory. You can also install the new version in a new directory and do a copy of your own files. Then, before using these files with the different modules, open successively the ".dat" files with EME Setup to update them then save them.

3.5 Information notes

3.5.1 Note 1

The RIG dialog uses the OmniRIG library created by Alex Shovkoplyas, VE3NEA. More information about OmniRIG at : http://www.dxatlas.com/OmniRig/ .

If you wish to manage your transceiver (RIG) with the "Tracking" program, then you must run the install program OmniRigSetup.exe supplied with EME System (or download the last version and install it).

OmniRig can support 2 simultaneous RIG manager. So you can run another one in parallel with the tracking program. I have tested HamPort (compatible with OmniRIG). Download it at : http://www.dxsoft.com/en/products/hamport/

3.5.2 Note 2

The terrestrial map was created with the Great Circle Map created by Roger SM3GSJ. A set file for GCM is included (emesyst.set). Run GCM, load the setting file and then just put your locator.

Make your own map and save it as "map.bmp" name in the EME System directory. Download GCM at http://hem.passagen.se/sm3gsj/gcm/download.htm

If you prefer, send me your locator via email (*jj@f1ehn.org*) and I will send you the right map for your location.

3.6 UNINSTALL

From the windows setup panel, start the "add / remove" program. Then, select "EME System" and press OK. Follow the windows instructions.

4   FRONT-END MODULE "LAUNCHER"

4.1   Description

The front-end module "Launcher" is a new man to machine interface (user interface) which concentrates the launch of the different modules. It allows creating shortcuts and so launching directly your favorite program with your favorite setup file.

4.2   Run LAUNCHER

To run Launcher software, click on his icon in the EME System menu.

An introduction screen (logo) is displayed for about 1 second and then an interface window appears (see fig. 2).

Now, you are able to do the following action :

- Select a "*.dat" file by clicking in the files list

- Delete this file by pressing the Delete button

- Create a new file by pressing the New button. This will open the EME Setup module with an empty Setup window (see chapter 5)

- Create a shortcuts (Icon) in the window start menu or on the window desktop by enabling one or both check boxes. Then press the wished button and Launcher will create the shortcut(s) and start the corresponding module. Then you can use the shortcuts to launch directly the wished module (as "Tracking" for example) with the wished data (as "Home.dat" for example).

- Run EME Setup (See chapter 5)

- Run Tracking (See chapter 6)

- Run Planner (See chapter 7)

- Run EME Calculator (See chapter 9)

- Run DXCC Edit (See chapter 8)

After an application launching was done, the "Launcher" window is reduced and available in the windows task bar. To use it again, click the EME system – Launcher icon to restore it. Then use Launcher as described above.

The "Launcher" window is automatically restored when you use the "New" menu in the other modules.

5   INITIALIZATION MODULE "EMESETUP"

5.1   Description

Before the first use of EME System or to adjust your EME station, you have to use EMESetup. Whit this module you are able to set all the parameters of your EME station grouped in 5 panels selectable with 5 tabs (see the EME Setup graph):

- Coordinates of the station (Call sign, latitude, longitude…)

- Interface: to define the dialogue between your interface and your computer

- Azimuth: to set the parameters of the antenna azimuth axis (encoder, end stop…)

- Elevation: to set the parameters of the antenna elevation axis (encoder, end stop…)

- EME station to enter all the characteristics of the station (power, NF, antenna gain, cables losses…)

- Correct to make or modify a correction file of your antenna angular measurement.

The parameters will be stored in a "*.dat" file.

5.2   Run EMESETUP

Run "EME Setup" software from the EME System interface "Launcher" (see chapter 4) or your own created shortcut (Start menu or desktop icon).

Then the EME Setup screen displays all the parameters.

Remark: EME Setup is able to read and convert the ".dat" file coming from the previous version (V6). Then, verify, complete this file and save it.

Use the "?" Help button to obtain a contextual help.

Remark: To create a new file, sometime it is quicker to load an existing file then to modify and save it with a new name. All parameters are stored in a ".dat" file. It is possible to give several names in order to store several configurations (Expeditions, stations, frequency bands...).

To edit a new file or do any other action, open the file menu and press "NEW". This displays the "Launcher" program on the screen to select a new data file (see chapter 4).

5.3   Coordinates tab

Enter the information about your EME station like Call sign, location… This information will be displayed in the tracking module.

Then enter the geographical coordinates of the station. EMESetup calculates automatically your locator grid square. You can also enter your locator to define the station coordinates but you have to know the location accuracy is then limited to about 1 arc minute and could decrease the tracking accuracy.

Complete this tab with the computer time information. The tracking module uses the UTC time and calculates it from the computer time with subtracting the time offset between UTC and computer time. This offset is equal to your time zone + you local summer time or daylight-saving-time information. Below, find an example at the French F6KSX station:

- Time zone = "+1" (hour to UTC)

- In May (summer period), Local Summer Time (= Daylight-saving-time) => "+1" (hour)
   o So, the total time offset between UTC and Computer time will be "+2" hours.

5.4 Interface tab

First, select the interface or protocol you are using:

- DDE Server : this option opens the "Tracking" program to any application with using a DDE channel. Then "Tracking" will send the Azimuth, Elevation and Doppler shift corresponding to the tracked source. If the source is different of the moon, the Doppler shift will be set to "zero". The Doppler shift could be "Mutual Doppler Shift" if you have selected it. The information is updated every 2 seconds. The accuracy is limited to 0.01° and 1 Hz. A separate document gives the information to develop a DDE interface (see http://perso.wanadoo.fr/f1ehn/download/DDE_dialog.pdf). The Green Heron engineers have developed a small middleware piece called GH Tracker. It converts the tracking data to DCU-1 protocol compatible with their Rotators as RT21 system (more information at http://www.greenheronengineering.com/TechSupport/support.html)

- ARS Interface EA4TX: this option allows the tracking module to send the source angular values to the EA4TX program (ARS Win) which is managing an ARS interface. The source position is transmitted via a DDE channel. The information is updated every 2 seconds. The accuracy is limited to 0.1°.

- Without (w/o) interface: select this option if you don't use any interface. So, you can use the tracking module without any dialog with the interface. Off course the tracking interface windows will not be displayed.

- F1EHN interface: If you are an user of the first EHN interface, select this option with the com port your are using (Ex : "EHN interf. On Com 2" allows the tracking module to use an EHN Interface plugged on the second serial com port of your computer).

- MK-EHN interface: If you are an user of the new MK-EHN interface, select this option with the com port your are using (Ex : "MK-EHN interf. On Com 1" allows the tracking module to use a new MK-EHN Interface plugged on the first serial com port of your computer).

- GS 232 protocol : with this option, you must also select the com port and the communication rate you are using (Ex : "GS 232 on Com 5" at 4800 bauds). Tracking program will use this serial com port to send the GS 232 protocol. EME system does not support all the protocol commands. The tracking module sends the source angular values corrected with the angular correction if you are using this feature (see Correct tab). The time interval is settable from 1 to 30 seconds between 2 updates (10 sec is recommended). The accuracy is limited to 1°. This mode is compatible with ALFASPID rotator (Rot2Prog interface => RAS or RAK rotator with more information at http://www.spid.alpha.pl/english/01.php), the F1TE interface (http://www.f1te.org/Tracker/trackeur_gb.htm), the G6LVB tracker (http://www.g6lvb.com/Articles/LVBTracker/) and all the rotator systems using the GS232 protocol.

- Easycomm1 protocol : with this option, you must also select the com port and the communication rate you are using (Ex : "EasyComm on Com 5" at 19200 bauds). Tracking program will use this serial com port to send the Easycomm1 protocol. EME system does not support all the protocol commands. The tracking module sends the source angular values corrected with the angular correction if you are using this feature (see Correct tab). The time interval is settable from 1 to 30 seconds between 2 updates (10 sec is recommended). The accuracy is limited to 0.1°. This mode is compatible with the known DL7AOT interface and all the rotator systems using the EasyComm1 protocol.

- EGIS using the EPR-103/203 interface box : with this option, you must also select the com port and the communication rate you are using (Ex : "EGIS on Com 5" at 1200

bauds). Tracking program will use this serial com port to send the EGIS protocol. EME system does not support all the protocol commands. The tracking module sends the source angular values corrected with the angular correction if you are using this feature (see Correct tab). The time interval is settable from 1 to 30 seconds between 2 updates (5 sec is recommended). The accuracy is limited to 0.01°. More information on the EGIS Bi-Axial-Rotor at http://www.egis.org/aroto_us.html.

- ProSisTel using the Control BOX "D" interface : with this option, you must also select the com port and the communication rate you are using (Ex : "Prosistel on Com 1" at 1200 bauds). Tracking program will use this serial com port to send the Prosistel protocol. EME system does not support all the protocol commands. The tracking module sends the source angular values corrected with the angular correction if you are using this feature (see Correct tab). The time interval is settable from 1 to 30 seconds between 2 updates (10 sec is recommended). The accuracy is limited to 1°. More information on the Pro. Sis. Tel system at (http://www.prosistel.net/home-e/default.html).

Then you have to enter the other information depending on the interface selection.

If you are using the 8-bit measurement (for polarization or signal) then enter the range and the offset measurement you are using. This signal input is very practical to do an automatic antenna diagram measurement with EME System V5 or V6. Use the contextual help "?" to have more information.

The majority of EMErs use the tracking interface with a normal mode. But with enhanced positioning system, there are some possibilities to manage the rotation speed of the antenna. So, because this use is very specific, the information about "Speed control" and "Rotation modes" is included in a separate documentation available in my web site.

To finish, if you are using the new MK-EHN interface, you have to run the MK-EHN setup program to set all the parameters. Follow the following instructions:

- Press the « setup » button. A new frame appears. Plug on the MK-EHN interface
- Open the com dialog and read the board setup
- Now, you are able to modify this setup. For more information read the MK-EHN interface chapter.
- To finish, write the new setup in the board PIC Eprom with pressing the "write setup" button. Then quit this frame.

5.5 Azimuth tab

The tracking module uses a hysteresis range to suppress a pumping effect on the antenna position. Moreover, this hysteresis allows reducing the time when the antenna is rotating to reach the source position with stopping the rotation after the source position. See the hysteresis graph and the "Considerations on an automatic tracking system" chapter.

The end stops values are used in the tracking module. So, the tracking module will not allow the antenna rotation above the end stops values. However, in rare case of crash or anything else the new MK-EHN interface board includes crash stops normally set outside the end stops values.

To set the azimuth axis, see the angular setup graph.

The azimuth axis has now 2 parks position. In the new EME System V5, a maintenance position was added to help the operator in the maintenance operation. The running of this maintenance position is a little bit different. Because EME Setup allows the operator to set an elevation maintenance position under the elevation end stop (with a warning), the tracking module will reach the azimuth maintenance position before to allow the elevation positioning.

The "without stop" option checked allows putting the zero encoder position inside the range of azimuth measurement (encoders, like USD A2, have no stop). Else, the zero encoder position must be outside the antenna rotation range (Often, the potentiometers have mechanical stop).

The "Reverse rotation" option checked allows reversing the reading of the angular position measured with the angular encoder like :
    True Angular position = 360° - angular position reading.

EME System now supports the encoder using Binary, BCD or Gray code via the "Format" list. *Use the contextual help "?" to have more information.*

5.6 Elevation tab

Like for the azimuth axis; the tracking module uses an hysteresis range to suppress a pumping effect on the antenna position. Moreover, this hysteresis allows to reduce the time when the antenna is rotating to reach the source position with stopping the rotation after the source position. See the [hysteresis graph](#) and the "[Considerations on an automatic tracking system](#)" chapter.

The end stops values are used in the tracking module. So, the tracking module will not allow the antenna rotation above the end stops values. However, in rare case of crash or anything else the new [MK-EHN interface](#) board includes crash stops normally set outside the end stops values.

To set the elevation axis, see the [angular setup graph](#). The elevation axis has now 2 parks position. In the new EME System V5, a maintenance position was added to help the operator in the maintenance operation. The running of this maintenance position is a little bit different. Because EME Setup allows the operator to set an elevation maintenance position under the elevation end stop (with a warning), the tracking module will reach the azimuth maintenance position before to allow the elevation positioning.

The "without stop" option checked allows putting the zero encoder position inside the range of elevation measurement (like USDigital A2 encoder : it has no stop. Else, the zero encoder position must be outside the antenna rotation range (Often, the potentiometers have mechanical stop)

The "Reverse rotation" option checked allows reversing the reading of the angular position measured with the angular encoder like :
    True Angular position = 360° - angular position reading.

EME System now supports the encoder using Binary, BCD or Gray code via the "Format" list. *Use the contextual help "?" to have more information.*

5.7 EME Station tab

Here enter the different parameters of your EME station. Because these are very common values there is no specific help.

The "Base station" value will be displayed as a default value Rx (or Tx) display in the tracking module when you will use the RIG manager function.

The 'Local Oscillator" value will be used by the tracking module to calculate the right RF frequency you are using for the EME traffic with adding the Local Oscillator frequency to the Base station frequency. Thus, all the Local Oscillator offset could be corrected.

The frequency band is used by all the modules for all the Doppler shift calculations. The frequency band must be equal to Local Oscillator frequency + Base station frequency (+/- 1 MHz).

If you have no conversion in your receiver (Ex: 432 MHz band with a 432 MHz transceiver), set the local oscillator to "0". 2 examples are showed below:

- Band = 10368 MHz, LO = 10339.8 MHz, Station = 28.3 MHz => RF = 10368.1 MHz

- Band = 432 MHz, LO = 0, Station = 432.050 => RF = 432.050 MHz

5.8   Correct tab

The CORRECT module helps you to make or modify a correction file of your antenna angular measurement. With this file, the Tracking module is able to correct the drift of your mechanical antenna system by adding the correction value to the angular measurement.

Most often, the drift is depending on both azimuth and elevation position (see considerations on an automatic tracking).

The Correct tab includes 2 parts, the position offset and the angular correction table. The EME Setup (Correct) figure shows the tab and main features.

5.8.1   Position offset

The "Position offset" box allows setting the true antenna position. Enter the true antenna position when the encoder displays "0" or enter an estimated offset between the encoder display and the true antenna position. Then :

True Antenna position = Encoder display + Position offset

For DDE or serial protocols, the position offset is added to the source position, then :

True Source position = Calculated source position + Position offset

See also the chapters 5.5 and 5.6 about the setting of the azimuth and elevation tabs.

5.8.2   Angular correction table

EME Setup creates automatically a ".tcv" file if the "Use angular correction table" box is checked (Ex : test_mk1.tcv for the data file test_mk1.dat). Tracking will use this file automatically if the box is checked.

You can use the mouse or the keyboard arrows to move into the lists.

 Remark: the maximum correction value is +/- 5 degrees.

5.8.2.1 Azimuth correction

Type the azimuth or elevation correction which depends on the Azimuth position measurement.

This correction is usable to correct an azimuth reading error (ex: non linearity of encoder) or / and a non verticality of the antenna tower.

5.8.2.2 Elevation correction

Enter your elevation correction which depends on the elevation position measurement.

This correction is usable to correct an elevation reading error or / and a mechanical tilting problem (the antenna is bending out of shape when you are tilting it).

5.8.2.3 Results off the correction

The azimuth and elevation results within the tracking module using a F1EHN compatible interface will be :

- True_Az_Meas = Az_Meas + Correct_Az(Az_Meas)

- True_El_Meas = El_Meas + Correct_El(Az_Meas) + Correct_El(El_Meas)

The Tracking module makes a linear interpolation of the correction inside the 10° azimuth or elevation steps and adds the correction value to the angular measurement on each axis.

For DDE or serial protocols exchanges, the measurement of the position of the antenna is not permits. So the angular corrections are added to the position of the tracked source. So, in this case, the sent data for the angular position of the source are :

- True_Az_Source = Az_Source + Correct_Az(Az_Source)
- True_El_Source = El_Source + Correct_El(Az_Source) + Correct_El(El_Source)

5.9   File Menu

Use the file menu with clicking "Save" to store all the parameters. EME Setup does a complete test and if the values are right, it stores the parameters in the dat file. If there is one or more wrong values, EME Setup displays an error message and open the tab where the mistake is. Then, enter a new right value.

Use the **"Save as..."** function to save the file with another name after your modifications. Like for the save function, EME setup does a complete test on all the parameters.

Press the **"Quit"** function to stop EMESETUP.

Press the **"New"** function to restore the "Launcher" window and open another or a new file.

6   REAL TIME AND CONTROL MODULE "TRACKING"

6.1   Description

The TRACKING module is capable, with a high accurate calculation, to handling an EME station in real time (Automatic tracking of sources, traffic periods, Doppler, polarization, signal level, common window, sky noise temperature, Rx/Tx management...).

The tracking graph shows the main functions of this module.

6.2   Run Tracking

Run the "Tracking" software from the EME System interface "Launcher" (see chapter 4) or your own created shortcut (Start menu or desktop icon).

Remark: If you wish to use a tracking interface, you must before plug on it.

Tracking read the data and init files then the module displays its main and the interface windows (see tracking graph).

Remarks: If you are running "Tracking" without an interface (No com, DDE or protocols running), the interface window is not displayed. If a "*.tcv" file exists (with the same prefix of the "*.dat" file), the Tracking module load it automatically (see the Correction chapter).

Remarks : During a DDE or protocol dialog, Tracking will not send the angular information if the source elevation is under -10°.

6.3   Main window

6.3.1   Menus

The main window has the following menus:

6.3.1.1   "File" menu

The "File" menu allows the following functions:

- Reload : to reload the same "dat" setup file. Very useful after an update of the current setup file or if you wish to restart with a plugged interface.

- New : to display the "Launcher" program and then do any other action. Close the tracking program.

- Quit: to quit "TRACKING"

- Save settings : If checked, this menu allows saving (Track.ini) the main tracking windows parameters when the user quit the program. Next time, the Tracking module will start in the same state. The different saved parameters are :
    o Main window position on the screen
    o Main window options (save settings on/off, Echo mode on/off)
    o Traffic tab parameters (sked man. Visible, Doppler reference, RIG 1 or 2, RIG offset mode, max offset, option VFO, Freq tuner (RIG or RF)
    o Fixed source position (Az & El)
    o Google Earth display : Range view in meters for DX, Common window and sky mode (could be change manually with note pad – default are 1000, 15000000, 100000000)
    o Interface window position on the screen
    o Display parameters of the interface : Source position or offset, signal or polar, angular offset displayed or not)
    o RIG window position on the screen

- o Diagram window position on the screen
- o Angular parameters (Angle and Step) of the antenna diagram measurement.

Arrange the windows of tracking as you prefer on your screen and then save the parameters with the help of the file menu and "save settings" sub menu. Check, then uncheck the "save settings" menu to save and fix the settings of the tracking module.

6.3.1.2 "Display" menu

The "Display" menu includes the following sub-menus :

- Google Earth : a link to launch GE and to display the DX location or the common window viewed from the source. Moreover, via the Skymap tab, it is possible to display into GE the sky information around the antenna position. To stop the link to GE, uncheck the Google Earth menu. The link to GE is renewed every traffic period.
  Please, refer to the "EME_Ant_DB.pdf" file for more information about this feature.

- Reduced display : Tracking displays only the Source, UTC and Traffic information.

- Normal display : Tracking displays all available information.

6.3.1.3 "About…" menu

 The "About…" menu gives information about the software.

6.3.2 Tabs selector

The main window concentrates information on a tabs selector to allow a very quick and clear access to the different functions. The available tabs in this version are :

6.3.2.1 Setup tab

This tab displays :

- General parameters: The text frame displays the general setup parameters (coordinates, traffic, frequency, interface dialog…)

- Tracking parameters: If checked, the text frame displays the tracking setup parameters (angular configuration, level or polar measurement…)

- More parameters : If checked, the frame displays :
  - o The setup file used and the correction file if it exists
  - o The angular tracking information (encoder position, applied offset and correction, corrected antenna position, speed information if available.
  - o Setup button : this button allows directly opening the current dat file with EME Setup. After update save the dat file and reload this one with the file menu

6.3.2.2 Sources tab

This tab includes a source selector offering a complete choice of sources. It allows to select any source in the following categories :

- Radio sources and planets : Select a pre-programmed source among the radio sources, cold sky areas, planets, sun or moon

- RA and Decl file or input : It allows to create and manage your own sources database. Select a target source from the current database (list) or create a new one with pressing the "New" button and entering your source description (Name, Ra, Decl). Press the delete button to erase the highlighted source file. Then select the wished file and press the OK button. This enables the User defined source in the sources selector. Then check this source to use it into tracking.

- Fixed position (Az / El) : It allows to create an angular fixed source with entering the Azimuth and Elevation position. Then press the OK button. This enables the User defined source in the sources selector. Then check this source to use it into tracking.

- Horizons files : Select a data file coming from the Horizons* calculator and press the OK button. This enables the User defined source in the sources selector. Then check this source to use it into tracking.
  - Email Horizons : Ask to Horizons* the ephemerid of an object for a period of interest. Then, send the text email (raw text, no html). Check the Horizons answer with your email tool. Then, save the Horizons answer to the EME System directory as a text file. The file "object.txt" includes a list of the object. Edit and modify it to add or remove objects. Check the last version of "object.txt" on my web site.

Note : If checked, the check box "Local reference" allows to interrogate Horizons to obtain data for the use of a manual tracking. Horizons will return data like Az, El of the source. Don't check this box for a normal use of the Horizons data with Tracking (Tracking uses geocentric data from Horizons).

- Satellites via DDE : It allows to link the tracking program to a satellite program like "NOVA for Windows", "Sat-Explorer" and SatPC32. The "SATELLITE" program must run before starting the DDE dialog. Select the wished program. Then tracking displays the satellite position and it allows to track this object in real time. With this feature, the users of the interface board could track the satellites with their EME antennas.

- Source defined or/and selected in the different categories : a box appears in the source selector to enable the use of a user defined source like RA & Decl, Fixed position or Horizons file.

The fixed source could be used to track a beacon (generator) to do an antenna measurement. Of course it is possible to do an automatic antenna diagram measurement (if it is available).

Horizons : is a calculation tool and an objects data base of the Jet Propulsion Laboratory (JPL). More information at : http://ssd.jpl.nasa.gov/?horizons

6.3.2.3 Terrestrial tab

This tab brings a useful help for the operator using their EME antenna for the terrestrial traffic. The "Terrestrial" tab displays (see the "terrestrial" tab graph) :

- A local map : It displays the antenna position with a red line (only if you are using a compatible F1EHN interface). Click on the map to automatically calculate the angular beam (blue line). The tropo map is created with the Great Circle Map created par Roger SM3GSJ. A set file for GCM is included (emesyst.set). Run GCM, load the setting file and then just put your locator. Then make the map and save it as "map.bmp" name in the EME System directory. If you prefer, send me your locator via email (jj@f1ehn.org) and I will send you the right map for your location. The map.bmp must have 271*271 pixels (4065 tips).

Download GCM at http://hem.passagen.se/sm3gsj/gcm/download.htm

- DX location : enter the DX location (grid square) and press enter. Then the tab displays the distance and the antenna beam

- Antenna beam : Use the calculated angular values or enter the Azimuth and Elevation of the wished beam. Then press the "Go to" button to beam the antenna in this direction.
If you are using a DDE or serial protocol dialog, check the "fix. source" option to use this value as a fixed source and send this position to the DDE channel or serial port.

6.3.2.4 Traffic tab

This tab is dedicated to give a help around the EME traffic. It is separated in 2 main frames (See the Traffic tab graphic).

- "Rig" frame : it allows managing automatically both VFO of your transceiver (RIG) on condition that it is compatible with a CAT (computer aided transceiver) dialog on both VFO A and B. Enable the dialog by pressing the "On/Off" button (see below) and check the RIG setup with a CAT running and adjust the setup dialog (see "Set" button below and/or check the function of your transceiver with the "Client" program available on the Omnirig web site). Then the RIG manager will calculate only the second VFO reading the value of the active VFO.. The RIG interface had some option:
  - o "On/Off" button to enable or disable the RIG dialog.
  - o "Set" button to open a setup window. Available if the dialog is "On". The RIG frame title displays the dialog status (On line, Off line, not responding …). After pressing the set button a "RIG settings" frame is displayed. Choice the running of your transceiver (RIG) by clicking the "active VFO" or "both VFO" check boxes. Then, press the RIG dialog open button to adjust the setup dialog between Omnirig and your RIG. Two transceiver setups are available (1-2 option). An interface example is given in a separate file and shows a TS440 setup (https://f1ehn.org/wp-content/uploads/2023/07/download/TS440_Interface.pdf).
  - o Doppler management option : select how the RIG management have to manage the RIG; continuously, manually with pressing the RIG button (or "F5"), continuously if the Doppler offset is over the specified value (Ex : 250 Hz).
  - o Offset RX/Tx : Displays the offset between RIG VFO and RX/TX calculated frequency
  - o Remote window : Opens a remote window dedicated to the RIG management. It includes the same functions as the RIG frame (see below the chapter 6.10)
  - o VFO : Select what is the reference as the TX or Rx frequency. Then Tracking calculates the right frequency regarding the Doppler shift value. Use Rx as reference for classic EME with checking the RX check box or TX reference for the digital mode with checking the TX check box).
  - o Master : Select what the master of the frequency calculation is : RIG with reading the RIG VFO or RF with reading the RF tune value. It is possible to replace the Doppler shift value with the mutual Doppler value during a sked with a DX station. Then check the "Mutual Dopp." Option.
  - o RF Frequency : Tune or Enter the RF frequency (if Master = RF) then Tracking calculates the right RIG frequency regarding the Local Oscillator frequency and the Doppler shift value.

- "Sked manager" frames : With checking the "Sked manger display" option, it displays some features to help you in your EME traffic. The following functions are available:
  - o A grid text (or sked list) to note the information about your traffic
  - o A virtual warning led indicates you the next coming sked in the 10 minutes.
  - o Send a selected frequency sked to the traffic frequency. Tracking calculates automatically the Rx frequency and the Tx frequency whit Doppler shift correction (to start a sked).
  - o Save directly the traffic RF frequency, date and time into the list (during the traffic)
  - o Delete a selected item from the sked list
  - o Before your traffic period, you can edit a sked list with the window notepad and load it in the sked list to use all this information during your traffic
  - o You can save your correction or addition in the list or erase this list
  - o The module scans the sked list to find the double call sign and marks it with +------+ symbols.

6.3.2.5 Sky Map tab

This tab is dedicated to the astronomical information (See the [Sky map tab graphic](#)). It displays :

- Brightness sky map: this frame shows the locations of the current source and radio sources and your radio electric horizon. If you are using a F1EHN compatible interface, this frame displays also the antenna position on the sky map. A colored scale (isothermic curves) gives the sky noise temperature at the frequency.

- The brightness sky map includes a Google Earth button allowing to beam the antenna position into the sky tool of Google Earth. Then GE displays the sky around the antenna position. The Google Earth dialog must be enabled before using this feature via the "Display" menu.

- A few astronomic information, updated at each traffic period, are available like:
    - The phase of the moon (icon)
    - The Moon's geocentric Greenwich hour angle (GHa) and declination (Decl)
    - The extra path loss to the perigee due to the actual distance between moon and earth
    - The Moon range
    - The sky noise temperature of the moon background at the frequency

6.3.2.6 World map tab

This tab is dedicated to the EME traffic (See the [World map tab graphic](#)). It displays :

- The common window world map with the footprint of the selected source. The module calculates also the moon position and displays it on the world map with corresponding the GHa to the Longitude and the Declination to the Latitude axes.

- This tab includes a Google Earth button allowing to visualize the common window viewed from source or the location around the DX location (selected on the DXCC database or grid via grid square. The Google Earth dialog must be enabled before using this feature via the "Display" menu. Moreover, this feature allows to display the photo of EME antenna available under Google via the "EME antenna photos database".

Please, refer to the "EME_Ant_DB.pdf" file for more information about this feature.

- The common EME parameters are displayed with selecting a DXCC in the list database or typing the DXCC or Locator grid square. The DX location is displayed on the world map. Then the common window frame displays:
    - The moon position for the DX station
    - The Doppler frequency shift at the DX station
    - The Doppler frequency shift (Mutual Dopp.) between the station and the DX station
    - The polarization offset between the station and the DX station
    - The distance between the station and the DX station

Remark: To cancel the DX station display, clear the DX or locator in the DX list box.

6.3.3 Fixed frames

There are 3 fixed frames. They display :

- The angular position of the selected source. The operator can quickly change the source with the 3 icons of the moon, sun and cold Leo area. These icons are disabled during the tracking operation (like the file and source tab).

During a DDE or serial protocol dialog, you must enabled the "Send data" check box to allow sending the angular (Az/El) information.

- The UTC coordinates (date and time). Tracking displays the "Local summer time" or

"Daylight saving time" information.

- The traffic information with the traffic period, the elapsed time during the period, the traffic RF frequency and the Doppler shift. The gauge "elapsed time in the period" blinks for 10 seconds before each new period. The gauge is green during the Rx period and red for the Tx period. The Doppler shift frequency is continuously updated. To adapt the traffic management (period duration, First or second period) click one of two button. You are able to change the first to second period or conversely second to first. The second button allows selecting the period time duration and it is adjustable from 1 to 10mn (1, 2, 2.5, 5 and 10 mn) with clicking with right (decrease) or left button (increase).

6.4   Antenna diagram measurement window

To open the window, select the antenna menu of the interface window, then click on the "Diagram meas." Menu. The window appears and displays (see Measurement tab graphic) :

- Measurement information and progress bar during the measurement time

- Results for both angular axes after a complete measurement like
  o -3 dB aperture
  o Beam offset
  o Aperture diagram
  o Cursors measurement

- List and management of the previous measurements

The chapter 6.10 explains how to run an antenna diagram measurement.

The antenna diagram measurement is only available with the use of a F1EHN compatible interface.

6.5   Interface window

The interface window has the following menus and fixed frames.

6.5.1   "Antenna" menu

The antenna menu includes the following functions:

- Az/El Position: automatic pointing to an asked position (see below the chapter 5.x)

- Autotrack : enables or disables the automatic tracking of the selected source (see below the chapter 5.7)

- Park => Parking pos.: the antenna is automatically pointed to the park position

- Park => Maintenance pos.: the antenna is automatically pointed to the maintenance position with firstly joining up the azimuth position then the elevation. Tracking allows the antenna elevation to go down to the elevation end stop.

- Drive (motor) : starts or stops the motors drive in the speed control mode 3. Not available in the other speed control mode.

- Absolute position: the interface window displays the antenna position (Azimuth and Elevation)

- Offset / source: the interface window displays the offset position between the antenna and the selected source

- Diagram Meas.: Open the "Antenna diagram measurement" window to permit the antenna diagram measurement or visualization (see below chapter 6.10)

6.5.2 "Display" menu

- Level meas. or Polar meas.: Enable or disable the display of the level or polar measurement (set with the EME Setup module)

- Angular offset adjust.: Permits to adjust the angular setting with adding some control to adjust the position offset on both axes. (Very practical to set the azimuth and elevation antenna position during an automatic diagram measurement. The changes are not saved. You must put the new values in your "dat" file setup).

- Save Track.ini: save the screen configuration (same as main window menu).

6.5.3 Fixed frames

The fixed frames of the interface window displays the following information or functions:

- The antenna position (absolute or offset to the source) in degrees

Remark: If an angular correction file is used then the antenna caption will be "Antenna (+tcv)" (tcv: Tracking Correction Values). To use this function see the chapter Correction.

- The antenna frame includes all the control to manage the antenna rotation :
    o The arrows keys (like the keyboard arrow keys) permit the manually controlled antenna rotation. First click starts the rotation. A new click stops it.
    o The "P" button controls the parking antenna. During the parking rotation or maintenance rotation (then Pm button) the operator can press the P or Pm button to stop the antenna rotation
    o The "Auto Track" button enables or disables the automatic tracking of the selected source (see below the chapter 6.7)
    o The "Motor drive" button (only available on the speed control mode 3) starts or stops the motors drive in the speed control mode 3.
    o The angular offset control permits to adjust, in real time, the antenna angular position on both axes.

- The polar measurement (set with the EME Setup module). The polarization measurement displays the feed polarization to the horizontal with the parameters defined in EME Setup.

- The level measurement displays:
    o The average value of the received signals (noise measurement)
    o The level offset value (for relative measurement)
    o The amplitude of the received signals

Remark: This display is updated every 20 measurements. The average value is also used for the antenna diagram measurement.

6.6 Manual positioning

The High, Low, Right, Left arrows control the antenna position. Press the key (Keyboard or icon) to start the motor (High=High, Low=Low, Right=CW, Left=CCW). Press again the key to stop the antenna rotation.

The arrow keys are usable only if the Interface windows is the active window. If the active window is the "Main window" then the arrow key are usable to browse the tabs selector

6.7 Automatic positioning

To run this function, select the "Antenna" menu and click on "Az/El Position" or press "F1". The "Terrestrial" tab is automatically displayed. Enter the azimuth and elevation values and press the "Go to" button. The antenna rotates automatically towards the new position. You can use this function to point the antenna to a beacon or in a specific position.

Remark: To point a beacon or a DX in a terrestrial QSO, you can enter the DX locator grid square in place of the azimuth value. Tracking will propose the calculated azimuth then accept this value to point it.

6.8   Automatic tracking

To run this function, select the "Antenna" menu and click on "Auto Track", or click on the icon "Tracking", or press "F3". The antenna rotates automatically towards the source position. The drive starts when the angle between the target and the antenna is greater than the "hysteresis start" value. The drive stops when the angle between the antenna and the target is greater than the "hysteresis stop" value (see Azimuth/Elevation setup).

Remark: The drives will stop when the antenna position will be equal or over the angular end-stop.

6.9   Noise measurements with the sun or the radio sources

The tracking of a radio source allows the checking of an EME station by looking at the difference in level between a noise source and a quiet source.

The antenna beam is towards a quiet sky ("Sources" menu then click Pictor, Leo or Aquarius cold area). In the interface window, press the offset button (or F8) to display a zero average value of the sky noise. Remarque : F7 disable the offset function as a click to depress the button.

Then, the antenna beam is towards the sun ("Sources" menu, "Sun"). Read the sun noise excess in the "Average signal level" window.

Remark: The measurement accuracy depends of the signal level measurement setting in the EME Setup module. Use the EME Calc module (chapter 9) to evaluate the performance of your EME station.

6.10 Automatic antenna diagram measurement

The good efficiency of an EME station supposes the antenna diagram is aligned to the mechanical positioning system in both axes. Else, the antenna points away the target and adds some losses in the EME budget.

From the EME System V5, the tracking module permits to do an accurate measurement of the antenna diagram (you must use a 100% compatible F1EHN interface to do this measurement).

To run this function, click the antenna menu then select the Diagram Meas. function.

The "Meas." tab is shown inside the main window (see the Tracking graph).

Then set the angular scan and step measurement values. The Tracking module proposes you both values as a function of the tracking hysteresis setting. To launch a diagram measurement you must before start an automatic sun track.

Then the Tracking module does automatically the complete measurement and displays the results as a curve on both axes and the diagram aperture and beam offset. The measurement is stored in an "AD+date+time" file.

Tracking will store the parameters measurement into the "ant" file. If you wish to read this parameters check the "Setting" check box. Tracking will display the tracking parameters used during the antenna diagram measurement.

If you have done a diagram measurement during a high antenna elevation, the azimuth diagram (or aperture) will be inaccurate. So, the new V6.0-Rev1 adds a new function to

correct the azimuth measurement regarding the elevation angle. Now, if you check the box "Az vs El", tracking corrects automatically the Azimuth diagram with :

Real Azimuth aperture = Meas. Azimuth aperture * cos(Elevation)

Remarks: During the measurement, the Tracking module tracks continuously the sun; so a long time measurement doesn't add any measurement mistake. On microwave bands, it is also possible to do a scan around the moon (see the supplied example files). At any time you are able to display or erase a stored measurement file. The displayed diagrams are made with an (S+N)/N measurement. For excess noise lower than 10 dB, the 3dB aperture calculation will be inaccurate.

6.11 RIG manager window

This window is dedicated to give a help around the EME traffic and the RIG management like the RIG frame into the traffic tab. It allows managing automatically your transceiver (RIG) on condition that it is compatible with a CAT (computer aided transceiver) dialog (see above the Traffic tab). The RIG window had some options and functions :

- Click to the RIG status indicator to enable or disable the RIG dialog. This indicator is "Green" if the dialog is enabled and "Red" is the dialog is disabled. The dialog uses the setting adjustable into the "Traffic" tab (see above).

- Doppler management option : select how the RIG management have to manage the RIG; continuously, manually with pressing the RIG button (or "F5"), continuously if the Doppler offset is over the specified value (set into the "Traffic tab").

- Offset RX/Tx : Displays the offset between RIG VFO and RX/TX calculated frequency

- VFO : Select what is the reference as the TX or Rx frequency. Then Tracking calculates the right frequency regarding the Doppler shift value. Use Rx as reference for classic EME with checking the RX check box or TX reference for the digital mode with checking the TX check box).

- Master : Select what the master of the frequency calculation is : RIG with reading the RIG VFO or RF with reading the RF value. It is possible to replace the Doppler shift value with the mutual Doppler value during a sked with a DX station. Then check the "Mutual Dopp." Option into the "Traffic tab".

- RF Frequency : Enter the RF frequency (if Master = RF) then Tracking calculates the right RIG frequency regarding the Local Oscillator frequency and the Doppler shift value.

6.12 Keyboard functions

Some keys of the computer keyboard are preprogrammed to do specific function like :

F1 : Automatic positioning

F3 : Automatic tracking

F5 : Reset the frequency RIG offset

F7 : Disabled signal offset measurement

F8 : Set the signal offset measurement

F11 : Main window active; then the arrow key are usable to browse the tabs selector

F12 : Interface window active : then the arrow keys are usable for antenna positioning

7   EME PLAN MODULE "PLANNER"

7.1   Description

The Planner module helps you to plan the EME activity, to prepare your skeds or traffic periods with calculating and displaying the Moon location, DX Common window, Doppler shift, polarization offset, sky temperature, phase of the moon..... The planner graph shows the main functions of this module.

7.2   Run Planner

Run the "Planner" software from the EME System interface "Launcher" (see chapter 4) or your own created shortcut (Start menu or desktop icon).

7.3   Main window

The main window contains the following main and sub functions.

- Icon toolbar
  - New : to select a new data file (open "Launcher" – see chapter 4)
  - Quit : to quit Planner
  - Email Horizons : Ask to Horizons the ephemerid of an object for a period of interest. Then, send the text email (raw text, no html). Check the Horizons answer with your email tool. Then, save the Horizons answer to the EME System directory as a text file. The file "object.txt" includes a list of the object. Edit and modify it to add or remove objects. This feature is also available via a dedicated icon.

Note : If checked, the check box "Local reference" allows to interrogate Horizons to obtain data for the use of a manual tracking. Horizons will return data like Az, El of the source. Don't check this box for a normal use of the Horizons data with Tracking (Tracking uses geocentric data from Horizons).

  - Clear screen : to close all the opened "Planer" windows.
  - Print : to print the results

- "File" Menu:
  - New: to select a new data file (open "Launcher" – see chapter 4)
  - Quit: to quit "PLANNER"

- "Display" Menu:
  - General setup : Display the station parameters.
  - Print : to print the results
  - Google Earth : a link to launch GE and display the DX location or the common window viewed from the source. Moreover, via the Skymap tab, it is possible to display into GE the sky information around the antenna position. To stop the link to GE, uncheck the Google Earth menu. The link to GE is renewed every new calculation.

Please, refer to the "EME_Ant_DB.pdf" file for more information about this feature.

  - Clear screen : to close all the opened "Planer" windows.
  - Email Horizons : Ask to Horizons the ephemerid of an object for a period of interest. Then, send the text email (raw text, no html). Check the Horizons answer with your email tool. Then, save the Horizons answer to the EME System directory as a text file. The file "object.txt" includes a list of the object. Edit and modify it to add or remove objects. This feature is also available via a dedicated icon.

Note : If checked, the check box "Local reference" allows to interrogate Horizons to obtain data for the use of a manual tracking. Horizons will return data like Az, El of the source. Don't check this box for a normal use of the Horizons data with Tracking (Tracking uses geocentric data from Horizons).

Please, refer to the "EME_Ant_DB.pdf" file for more information about this feature.

- o Save settings : save the screen configuration and the states of the different features into the "planner.ini" file. Next time, the Planner module will start in the same state. The different saved parameters are :
  - Forecast window position on the screen
  - Main window position on the screen,
  - Options of the main window :
    - Forecast duration (days)
    - Forecast step
    - Moon visible or not
    - Min elevation at home
    - Min elevation at DX
    - Month data begins at the 1st of month or today
    - Echo mode on/off)
  - Google Earth display : Range view in meters for DX, Common window and sky mode (could be change manually with note pad – default are 1000, 15000000, 100000000)
- • "About" Menu: Gives some information about the Planner module

7.4 Month EME data

The planner module opens a new window and displays as some curves the EME month data from the current date.

The displayed curves are:

- • Declination of the Moon

- • Extra path loss corresponding to the Earth to Moon distance

- • Sky temp degradation. Planner calculates the sky temp back ground of the moon and displays the noise power density ratio (degradation) between the background temperature and the cold sky temperature at the defined frequency. Not displayed but available on the microwave bands.

- • T Syst degradation. Planner calculates the new system temperature considering the new antenna temperature with the moon sky temp back ground. Then it displays the noise power density ration (degradation) between the new system temperature and the system temperature corresponding to the cold sky temperature at the defined frequency. Not displayed but available on the microwave bands.

The bottom of the month data window is dark to indicate the displayed values are bad EME conditions (like low declination, high path losses and high temperature degradation).

You can browse any date on this window with typing a new start date or with using both buttons "next month" and "back "

The month data window includes also a cursor measurement and you are able to measure at any date all the moon's data.

A sun icon indicates the proximity between the moon and sun.

Some captions indicate the WE dates during the month and are direct links to date entry of Planner. The date corresponding to the cursor position is also a direct link to the Planner date entry with clicking month data frame at the wished date.

7.5 EME Forecast

Enter a date to plan the EME activity. The "UTC" frame displays the UTC start date and the Forecast duration. You can modify these dates with the mouse and the keyboard with using the Calendar frame, the "Now" button to use the computer time. Then enter the :

- UTC time or press the step button to decrease or increase it.

- Step : it is the calculation step in minute

Enter the forecast options :

- Always: PLANNER displays all the results

- Moon visible: PLANNER displays the results if the moon is visible.

- Elevation low limits at Home and at DX to limit the forecast to usable period of traffic.

Then select the radio source which will be displayed with the moon and sun positions and press the "Display" button (List icon). Planner calculates all the steps and displays a new moon location window for each day which displays:

- The date, the start time and the end time of the results

- The call sign and the location

- The frequency

- The sky noise temperature for the moon position

- The extra loss (Loss/Perigee) due to the actual distance between moon and earth

- The moon declination for the start and the end time

- The UTC and local time

- The moon location and the Doppler frequency shift

- The phase of the moon (icon)

- The sun location

- The radio source location

If you wish to do a new calculation, change the parameters (date, time, radio source…) and press again the "Display" button.

Else, you can complete your forecast with a common window forecast (see below). Click the row of the forecast window list for the date and time you are wanting and these UTC coordinates will be sent to the UTC frame entries.

7.6 Common window forecast

If you know the date and time at which you wish a calculation then click on the wished time in the corresponding moon location window row. Then the UTC date and time will be directly usable.

To run the common window mode press the "Common window" button (globe icon). Then a new "common window" window appears. Its title including the source name (Ex: Moon), the compute date and time (see Graphic).

You can change the UTC date and time at any time. If you press Enter after a new UTC entry, a new calculation is automatically done.

The "Common window" window includes 3 different tabs :

- Sources
- Sky Map
- World Map

Select the source (moon, sun...) and modify the UTC date and time. Press the "display" button to view the EME common window.

7.6.1.1 Sources tab

This tab offers a complete choice of sources via a source selector interface. It allows to select any source in the following categories :

- Sun or Moon
- Radio sources
- Cold sky area
- RA-Decl file : User defined sources with entering RA and Decl coordinates of the source. It allows to create and manage your own sources database. Select a target source from the current database (list) or create a new one with pressing the "New" button and entering your source description (Name, Ra, Decl). Press the delete button to erase the highlighted source file. Then select the wished file and press the OK button. This enables the User defined source in the sources selector. Then check this source to use it into Planner.
- Horizons file : Select a data file coming from the Horizons calculator and press the OK button. This enables the User defined source in the sources selector. Then check this source to use it into Planner.

7.6.1.2 "Sky map" tab

The radio sky map shows :

- The brightness temperature of the sky at the traffic frequency.
- The brightness sky map includes a Google Earth button allowing to beam the antenna position into the sky tool of Google Earth. Then GE displays the sky around the antenna position. The Google Earth dialog must be enabled before using this feature via the "Display" menu.
- The location of the moon, sun and main radio sources on the sky
- The noise isothermic curves
- Your radio electric horizon at this time (see the window title)
- The Moon's geocentric Greenwich hour angle (GHa) and declination (Decl)
- The extra loss (Loss/Perigee) due to the actual distance between moon and earth
- The phase of the moon (icon)
- The sky noise temperature for the moon position (at the traffic frequency)

7.6.1.3 "World map" tab

- The world map shows the EME common window (or source's footprint) for the selected

source.

- This tab includes a Google Earth button allowing to visualize the common window viewed from source or the location around the DX location (selected on the DXCC database or grid via grid square. The Google Earth dialog must be enabled before using this feature via the "Display" menu. Moreover, this feature allows to display the photo of EME antenna available under Google via the "EME antenna photos database".

- The source angular positions (Azimuth and elevation) and the Doppler frequency shift if you are tracking the moon

- The DX location by clicking on the world map at the wished DX station location or typing a DX prefix or a locator grid square in the DX list box (see DXCC Editor to modify this list)

Remark : To cancel the DX station display, clear the DX or locator in the DX list box.

- The EME parameters between your station and the DX station like:
  o The moon position for the DX station
  o The Doppler frequency shift for the DX station
  o The Doppler frequency shift between the home and the DX stations
  o The polarization offset between the home and the DX stations
  o The distance between the home and the DX stations

7.6.2 DX to Station EME Forecast

If you have selected a DX station in the common window, the "List" button is enabled. Then, press it to obtain a list including all the needed EME parameters between your station and the DX station. Like EME Forecast, Planner creates a window per day which displays:

- The date, the start time and the end time of the results

- The call sign and the location of the home station

- The call sign and the location of the DX station

- The frequency

- The sky noise temperature for the moon position

- The extra loss (Loss/Perigee) due to the actual distance between moon and earth

- The moon declination for the start and the end time

- The UTC and local time

- The moon location for both station

- The phase of the moon (icon)

- The Doppler frequency shift and the polarization offset between the home and the DX stations

Remark: If the selected source is different of the moon, then some parameters (declination, sky noise temperature, Doppler, polarization...) are not displayed.

Press the "printer" icon or select the display menu then "print, common window" to print the complete page.

8 PREFIX AND COUNTRIES DXCC EDITOR MODULE "DXCCEDIT"

8.1 Description

The DXCC editor module helps you to edit the DXCC database, to modify or update the information, to create a new DXCC or delete obsolete information.

8.2 Run DXCC Editor

Run the "Planner" software from the EME System interface "Launcher" (see chapter 4) or your own created shortcut (Start menu or desktop icon). Then the module displays the main window including the main functions icons and the DXCC list.

8.3 Main functions icons

The icons permit the following functions :

- Save : to save the updates in the "dxccpref.dbr" file
- Search : to search a DXCC prefix in the database. Type the call or partial call you are searching. Then press enter or click Edit to edit it.
- Edit : to edit, modify or remove a DXCC from the list
- New : to create a new DXCC
- Quit : to quit DXCCEDIT.

8.4 "DXCC List" frame

This frame displays a list of the DXCC prefix. For each DXCC (a DXCC per row) the list gives the following information:

- The prefix
- The country
- The locator (Grid square)

Remark: To select a DXCC, click the list on the DXCC row. To edit it, double-click the row.

8.5 "Editor" frame

This frame allows you to modify or enter a prefix, a country, the latitude (deg, min) and the longitude (deg, min) or the locator (grid square) for the selected DXCC.

The editor main functions are:

- Remove: to remove a DXCC from the list.
- World map: to show the DXCC location
- Cancel: to quit the editor without modification
- OK: to quit the editor and save the modification into the list

Remark: If you remove a DXCC from the list, the update will be saved only if you save the DXCC list into the file dxccpref.dbr (see main function icons)

8.6 "World map" frame

The world map shows the DXCC geographic location. Press the "Exit" button to go back to the "Editor" frame..

9   EME CALCULATOR MODULE "EMECALC"

9.1   Description

The EME calculator module helps you to evaluate or to gauge the performance of your EME station. Use EMECalc to do an EME budget or to calculate the average performance of your station with noise measurement.

9.2   Run EME Calculator

Run the "EMECalc" software from the EME System interface "Launcher" (see chapter 4) or your own created shortcut (Start menu or desktop icon).

The EME Calculator window displays :

- A header frame including your (home) station parameters and the traffic frequency

- A "Print" button to print the results of the active calculator (EME or Noise)

- A tab selector with 3 tabs (EME budget, Noise measurement, and Help).

9.3   EME BUDGET

The EME budget uses the home station parameters (.dat file) and the DX station parameters (emecalc.ini file). See the EME calculator graph.

With these complete parameters, the calculator does an EME budget and displays the results. You can modify different values. Enter the new values then press the "calculation" button to allow the calculator to do a new calculation.

Save the DX parameters (if you wish) with the "Save DX info" button. Unlike previously, if you wish to reload the DX station parameters then press the DX "Default values" button to reread the emecalc.ini file. In the same way, press the home "Default values" button to recall the home station parameters (or press the "file" menu then "reload").

Press the "File" menu then "new" to select a new file with "Launcher" and do a new calculation. Press the "File" menu then "quit" to quit the EME Calculator software.

Select the "help" tab to read some information about the "EME budget" calculator. Select the "Noise measurement" tab to select the noise calculator.

9.4   NOISE CALCULATOR

The Noise calculator uses the home station parameters (.dat file). See the Noise calculator graph. With these complete parameters, the calculator does a noise estimation of your system and displays the results.

For the first calculation, the program uses the average quiet sun as a noise source and the Leo cold sky area as the cold source. You can change these sources with both combo boxes (noise and cold sources). Of course, the program allows you to use :

- 3 different laws of solar flux (quiet, average or maximum)

- a defined solar flux value. Download the solar flux information from a professional observatory and enter the solar flux value at the traffic frequency.   *The value must be in sfu (10^{-22} w/m²/Hz). Don't use the SFI (solar flux index measured at 10.7 cm).*

- the black body of the moon (at the perigee). Usable on the microwave bands.

- the ground temperature (290 K) to do a classic Cold Sky / Gnd measurement

- the area around a known radio source like Cassiopeia, Cygnus…

- a radiated flux of a known radio source (flux in Jy) and your local sky temperature (in K) at the traffic frequency.

Off course, you can modify the home station parameters. Enter the new values and then press the "calculation" button to allow the calculator to do a new calculation.

Remark: You can modify the simulated antenna temperature but the simulator will ask you to keep this new value only for the next or for all the calculations.

If you wish to reload the home station parameters then press the "Default values" button to reread the ". dat" file (or press the "file" menu then "reload").

Press the "File" menu then "new" to select a new file with "Launcher" and do a new calculation.

Select the "help" tab to read some information about the "Noise measurement" calculator.

9.5 HELP

The "help" tab displays some definitions and explanations about the EME and Noise measurement.

10 MK-EHN HARDWARE INTERFACE

10.1 Introduction

The Tracking module is specialized to provide in real time the tracking of various objects or astronomical sources.

The tracking of these objects can be made only through an interface between the program of calculation and management (Tracking) and the EME station (Receiver, Antenna, Motors…)

The current interface has perfectly performed its functions for 10 years and equips more than 160 EME stations distributed in 27 different countries. But today, it is becoming more difficult to obtain components necessary for its manufacture.

The following reasons:

- Need in pointing precision is increasing with the use of microwave bands

- The arrival on the market of absolute encoder with high accuracy

- The obsolescence of the technology used for the current interface

… led me to develop a new interface.

10.2 From the current interface to the new version

The origin of the new design appeared some years ago now. Besides the obsolescent technology, a few American stations had a desire to replace incremental encoders, that were relatively inexpensive but required relatively frequent calibrations, with more expensive to buy absolute encoders that provided a reliable and durable use. This required some new interface design for the absolute encoders.

Rex, KK6MK, had realized a prototype to equip WA6KBL and W6HD. The history of his board is described in the EME 2002 proceeding – Prague and on Rex's Internet site http://www.xertech.net/Projects/EMEboard.html. As he explains it, Rex had chosen to realize his prototype to replace the current interface but still use the EME System program which is given free of charge to the EME community.

These functions on the original interface were desired to keep:

- Communication via a serial port RS232 equipping most of the PCs

- 2 input ports in the 16-bit format for the antenna's Azimuth and Elevation

- Control of the movements of antenna by 4 relays CW, CCW, Up and Down

- 1 input port in the 8-bit format for the signals or polarization measurement

- LED indicating Tx or Rx period is active

- Blink a LED to indicate the board is talking with the PC.

The new design thus arises from Rex's prototype and numerous exchanges that defined the new interface as follows:

- Compatibility with the current interface by keeping these existing functions:
  - o Serial port of communications
  - o 2 *16-bit ports
  - o Control of the antenna rotation by 4 relays

- The 8-bit port was replaced by an analog input allowing connecting to various sensors such as potentiometers, detectors. Its use is identical for the measurement of the signal level or polarization. This new port avoids the use of an external A/D 8-bit coder.

An RS485 port allows the connecting of absolute encoders typical US Digital A2 whose specifications are on http://www.usdigital.com or other encoders using the same dialog like MAB or ETS encoders connected via a MABMPU board developed by Gary N8CQ.

- A LCD allows to give technical information to the user such as the periods Rx / Tx, the error messages, the display of position without the use of a PC

- The "Tracking" module of EME system includes an antenna rotation speed control function. So, the interface thus incorporates a digital coding of the information transmitted by "Tracking" and optionally can generate an analog voltage to control the antenna speed of rotation.

- The parameter setting of the interface is possible from the module EMESetup without use of a specific programmer.

10.3 Description of the new interface

To develop the new interface, the other criteria have been:

- Easy to build

- Compatibility "pin to pin" with the original interface (maintenance)

- Modularity of the functions (so options can be use or not)

- Update and easy parameter setting

- Important life cycle (at least 10 years) to pay off the development cost brought by the CAD of the circuit and the tools of manufacture of the PCB.

The use of components in SMD technology was chosen as its biggest life cycle. The modularity of the functions (options) allows to choice of implementing only the wished functions and possibly an evolution of the board according to the need.

10.3.1 Main function

The main function is built around a micro-controller Microchip PIC 16F877-4PT. The schematic is detailed in appendices 1 and 2.

This part allows:

- The dialogue with the PC via the serial port RS 232 through a circuit interface MAX202 and of a 9-pin connector.

- The programming of the PIC via a 10-pin connector ICP (In Circuit Programming). A microswitch isolates the PIC during the programming.

- Display with an optional LCD 16*2 linked with the connector SV2

- The control of the movements of antenna via 4 relays

- Analog input with a range from 0 to + 5V. This input could be used to read a polar measurement with a potentiometer or the received signal level with a compatible detector.

Remark: the connector P1 (96-pin) is also optional. It allows the compatibility with the first F1EHNinterface.

10.3.2 RS 485 option

The absolute encoders like USD A2 are read and controlled via a 6-pin RS 485 interface. If this function is not used, its wiring is not necessary. Its schematic is given in appendix 3. Remark: the specifications and the description of the encoders are available on the site of Digital US in *http://www.usdigital.com*

This interface also supports the use of MAB or ETS encoders from Megraton via the MABMPU interface developed by N8CQ.

Please, refer to the documentation "USD&MAB_encoder.pdf" and "USD_advices.pdf" available on the download page of my web site.

The A2 encoders dialog via a 6-pin SEI Bus. See information at :
http://www.usdigital.com/products/a2/

10.3.3 2 * 16-bit parallel inputs option

The "16-bit" function is necessary if the user wishes compatibility with the original interface design and to not use the RS485 absolute encoders. Otherwise, the cabling of this function is optional. Its schematic is given in appendix 4. The connecting of the data in parallel is described in appendix 5. The "Tracking" module allows data to be read from encoder in the binary, BCD or Gray (new) format .

Remark: the appendix 12 gives the schematic of the 16-bit // incremental encoder supplied by Darrell VE1ALQ. See at http://www.ve1alq.com/downloads/encoder/encoder.htm

10.3.4 Speed control option

The main tracking program can be set up to send error values that indicate how far the antenna is from the desired position. These values can then be used to control antenna movement speed, so the antenna moves faster if it is far from the target position. Part of the new board design adds two DACs (one for Azimuth, one for Elevation) that provide a voltage proportional to the angular offset. This can be used to control the speed of the motors driving the antenna.

In mode 2 (see documentation about "rotation_modes"), the voltage is unipolar (0 to 4V) and allows the motor drive voltage control if the motor system has a method to accept this. The relays of the board of interface are used to control the direction of rotation of the antenna as in the standard mode 1.

In mode 3, the supplied voltage is centered on 2 v and varies of +/-2 V from that (0 to 4V). With an external operational amplifier, the voltage can be easily shifted so that +2V error value gives 0V and the output is now bipolar +/-2V (or more) to pilot a servo-control of position. In this mode 3, the relays of the board are used by the Tracking module to switch on or off the servo-control. The direction of rotation of the antenna is only controlled by the voltage of control speed.

For both modes 2 and 3, Tracking includes an acceleration ramp in the speed control process. It permits a smoother tracking system with an automatic ramp of acceleration (about 2 sec of duration).

The schematic of the option is given in appendix 6. The wiring of this function is optional.

Please, refer to the "Rotation_modes.pdf" document for more information.

10.3.5 Wiring

The photo in appendix 7 shows the PCB equipped with its various options.

There no special recommendation. Just do a clean wiring job and be careful to avoid accidental short circuit between wires. If possible use a small soldering iron and a binocular (magnifying glass).

The PCB is available and to order see the conditions stored in my web site.

Please, refer to the "PCB_Wiring.pdf" document for more information.

10.3.6 Components

The appendix 8 lists all the components necessary for the implementation of a complete board. Some marks indicate the components of the various options.

The "Radiospares" references are given to facilitate the components order. However, verify that they did not change!!!

Please, refer to the "PCB_Wiring.pdf" document for more information.

10.3.7 Programming

The firmware that drives the PIC 16F877 is a standard Intel load module that can be loaded into the chip with any programmer that can program the Microchip PIC 16F877. The Microchip PicStart Plus and the DataIO plus48 have been tested..

It is possible to program the PIC on board via the ICP connector (SV5). The microswitch SW1 must be off (open circuit) during programming.

An ICP to programmer adaptor cable is detailed in the appendix 9. Connect your programmer to the board with this adaptor and program the PIC with the last firmware available on the EME System web page.

If you are using the PicStart Plus programmer, the chip can be programmed by using the MPLAB software. Then select the right PIC model, import the last HEX file, select 'PICSTART Plus -- Enable Programmer. Before starting to program the chip, verify that the following settings are indicated:

- o Oscillator   XT
- o WD Timer   OFF
- o PU Timer   OFF
- o Code Protect   OFF
- o Brown Out Detect   OFF
- o Low Voltage Program   Disabled
- o Data EE Protect   OFF
- o Flash Program Write   Enabled

After programming, the micro switchs must be switched on (close circuit).

You can find some information about the PIC, the programmer and the ICP method on the microchip web site: http://www.microchip.com

10.3.8 Running and test

To run the MK-EHN interface, connect the board to the power supply. Switch on the PS with starting with a low voltage and go up slowly to verify the voltage regulator running.

If the +5V coming stable with the PS over 8V, you can continue up to 12V.

Switch off the PS and restart again. If you are using the LCD, you can see the starting message "EME ctrl V2.01g" if it is the last version in use.

Else, plug the serial port computer with a crossed cable (see appendix 10).

Start EME setup and try to read the board setup (see setting below).

There is no tune.

Then plug your encoder and / or other input (see appendix 10). The RS485 input pin out is detailed in the appendix 3. The 16-bit parallel inputs are detailed in the appendix 4.

Start the Tracking module.

The time diagram of the complete RS 232 cycle is detailed in the appendix 11

Please, refer to the "Test_Signals.pdf" document for more information.

10.3.9 Setting

The new board is easily programmable with a specific program module available in the EME Setup module (Interface tab). This setting doesn't need any programmer. The PIC is programmed via the computer serial port (same port as the one used by the Tracking module)

This module allows to modify the different values stored in the PIC EPROM, like :

- USD encoders: enable the RS485 input to read the antenna azimuth and elevation

- 16b parallel inputs: enable 16-bit parallel input for azimuth and elevation

- Use crash stops: enable the use of the crash stops (see value below)

- Use speed control: enable the board to supply a speed control voltage

- Crash stops: enter the values in degrees for the 4 crash stops. These stops must be referenced to the "zero encoder" position. See angular graph.

- Analog functions: these are specific controls to manage the start of motors and the minimum voltage to have a slow speed. In a normal use, all these values are set to "0". Dedicated uses are described in the "rotation_modes.pdf" note.

10.3.10   Display

The LED blinking indicates the board is talking with the computer. The LED continuously turned on or off indicates the dialog is wrong.

The LCD is optional. But if you are using it, the displayed information are :

- Azimuth and elevation of the antenna (These values are the encoders reading and could be different from the Tracking display if you are using angular offset or correction)

- Rx or Tx period

- At the start, the firmware version is displayed. This firmware information is also available in the setting module when you are reading the board setup

- ^, v, <, > symbols indicating an angular position is over a crash stop

- ComX indicating the board doesn't receive any information from PC. ComX will appear if the dialog is stopped more than 3 seconds.

11 DOCUMENTATION REFERENCE (PDF FILE)

- PCB_Wiring
- DDE_Dialog
- Rotations_Modes
- Tests_Signals
- USD&MAB_Encoder
- USD_Advices
- EME_Ant_DB

Please, refer to these documentations to find more and updated information.

12 CONCLUSION

The system described allows easy and accurate, manual or automatic, control of the 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. I will also appreciate a short email with some information about your EME station and the EME System use.

My address:

Jean-Jacques MAINTOUX F1EHN

30 rue de Villacoublay

F78140 VELIZY

FRANCE

Email : **jjm_f1ehn@wanadoo.fr** or **jj@f1ehn.org**

The PCB is available and to order see the conditions stored in my web site.
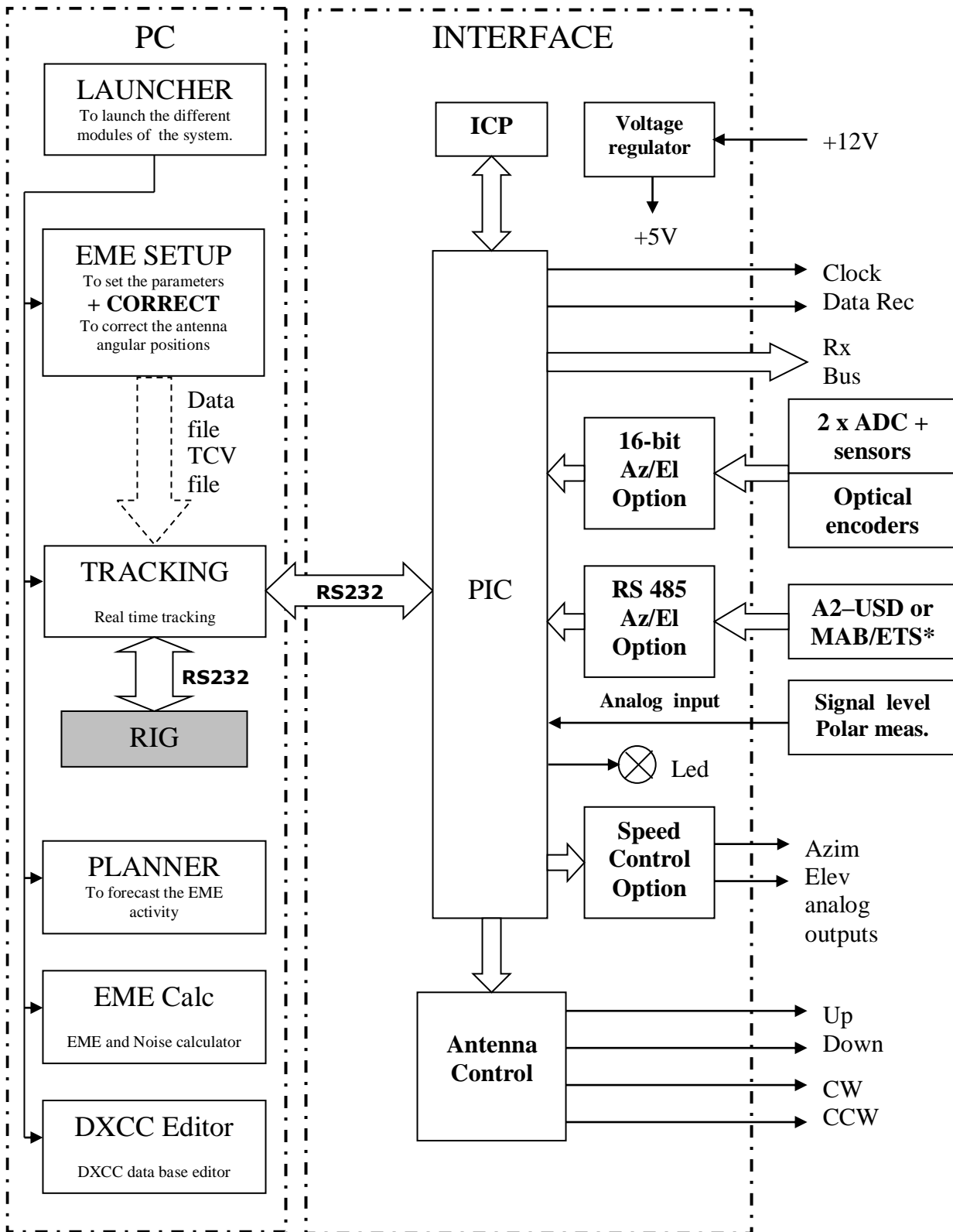
*Download the latest version at : **https://f1ehn.org/***

Updated : Dec 2023

BIBLIOGRAPHY

- ASTRONOMY WITH YOUR PERSONAL COMPUTER :
  - By Peter Duffet SMITH (1st Edition)

- PRACTICAL ASTRONOMY WITH YOUR CALCULATOR :
  - By Peter Duffet SMITH (3rd Edition)

- CALCULS ASTRONOMIQUES A L'USAGE DES AMATEURS :
  - By Jean MEEUS

- RADIOASTRONOMY :
  - By John D.KRAUS (2nd Edition)

- Lunar Tables and Programs from 4000 B.C. to A.D. 8000,
  - Michelle Chapront-Touzé, Jean Chapront,

- Determining the parameters of a Receive System with cosmic radio sources :
  - By Dragoslav DOBRICIC, YU1AW (VHF COM 1/84)

- RADIO NOISE and Interferences :
  - By ITT HANDBOOK (RF Engineer Chapter 29)

- Using the sun to characterize Radar systems :
  - By Arnold DOTY – Microwave & RF October 1987

- EME and Radio Astronomy :
  - By Luis CUPIDO, CT1DMK

- Antenna performance measurements using celestial sources :
  - By W H CURRY, Jr – W5CQ/W4RXY

- Spatial Polarization :
  - By Tim PETTIS, KL7WE

- What's different on 10 GHz EME :
  - By Joseph FEHRENBACH – DJ7FJ

- OmniRIG library
  - by Alex Shovkoplyas, VE3NEA. http://www.dxatlas.com/OmniRig/ .

- Great Circle Map
  - Roger SM3GSJ. http://hem.passagen.se/sm3gsj/gcm/download.htm

- Interface board compatible with F1EHN interface - EME 2002 proceeding - Prague
  - Rex ALLERS, KK6MK.

- EasyComm Interface specification
  - Chris JACKSON, G7UPN - http://www.amsat.org/amsat/ftp/software/win32/wisp/easycomm.txt

- Antenna Rotator System
  - Juan Pablo GARCIA, EA4TX - http://www.ea4tx.com/support/Setup_F1EHN.htm

EME System
by Jean-Jacques F1EHN

PC

LAUNCHER
To launch the different modules of the system.

EME SETUP
To set the parameters
+ CORRECT
To correct the antenna angular positions

Data file
TCV file

TRACKING
Real time tracking

RS232

RS232

RIG

PLANNER
To forecast the EME activity

EME Calc
EME and Noise calculator

DXCC Editor
DXCC data base editor

INTERFACE

ICP

Voltage regulator

+12V

+5V

Clock
Data Rec

Rx
Bus

PIC

16-bit Az/El Option

2 x ADC + sensors

Optical encoders

RS 485 Az/El Option

A2–USD or MAB/ETS*

Analog input

Signal level Polar meas.

Led

Speed Control Option

Azim
Elev
analog outputs

Antenna Control

Up
Down

CW
CCW

MAB and ETS encoders from Megatron need an MABMPU adaptor. A2 is an encoder type from US Digital. Read the "USD&MAB_encoders.pdf" note for more information

LAUNCHER

Direct launch of the different modules

Launcher : Example of use

Tracking home.dat

Then you will be able to launch directly your favourite program with your favourite "Dat" file.
Ex : launch Tracking with "Home.dat"

Creates an icon automatically on your desktop.

Delete the highlighted file or create a new file.

EMESETUP (1/2)

Save the file, New file with opening "Launcher" or quit EME Setup.

E.M.E System - Set Up - home.dat

File   Help   About…

Station

Callsign	Location	Height (asl)
F1EHN	VELIZY	175

Latitude

Deg	Min	Sec	n/s
48	46	14	n

Longitude

Deg	Min	Sec	e/w
2	12	30	e

Locator

< Convert

Computer Time

UTC +1   ?

☑ Local summer time

Coordinates

Latitude (°)	Longitude (°)	Locator
48,771	2,208	JN18CS

Station | Interface | Azimuth | Elevation | Radio | Correct
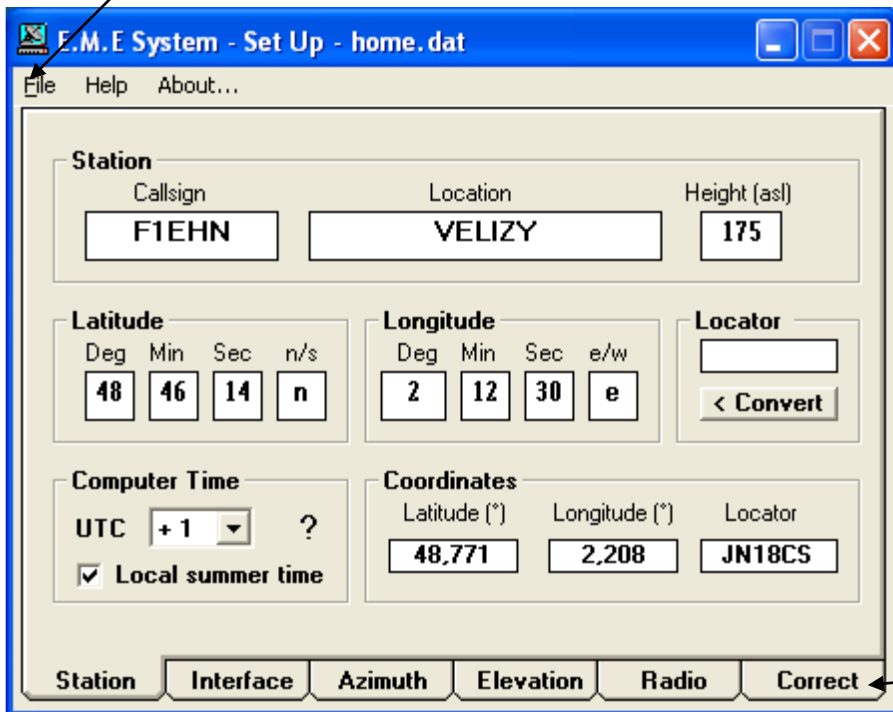
Select a tab to edit its parameters

First, select your tracking interface (or Without). Then select the com port used for the dialog. DDE or serial protocols (GS232, Easycomm..) are available.

E.M.E System - Set Up - home.dat

File   Help   About…

Dialogue with interface or rotor system

MK-EHN   ▼   Com 1   ▼   9600 Bauds   ▼

MK-EHN board setup

Run Setup

8 bits binary input

Range   Offset

Signal meas.   51   0   ?

Drive control

◉ Normal track : Direction and rotation are controlled by the Az and El relays

○ Mode 2 : Normal track + Interface displays an unipolar error information

○ Mode 3 : Direction and rotation are controlled by a bipolar error information

Speed control   **Usable only with a motor speed control interface !!!**

Auto 0.6   Decreasing below (°) 25   Man. step 0.5   Continuous ☐ ?

Station | Interface | Azimuth | Elevation | Radio | Correct

The time interval is settable for the DDE or serial protocols

Click on « ? » to obtain a contextual help

Click this button to set the new MK-EHN board (see below)

EMESETUP (2/2)

E.M.E System - Set Up - home.dat

File   Help   About...

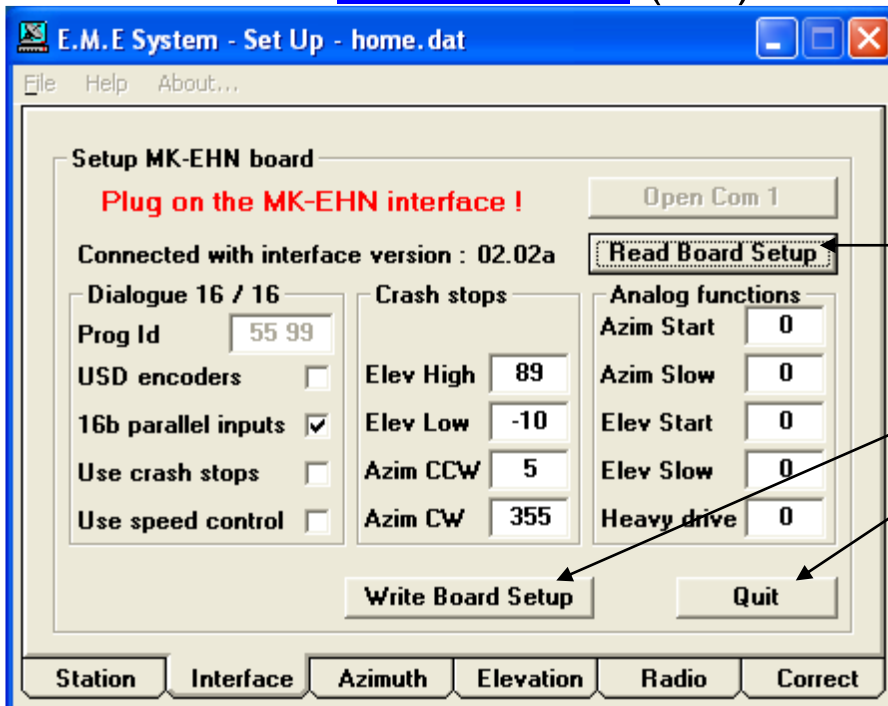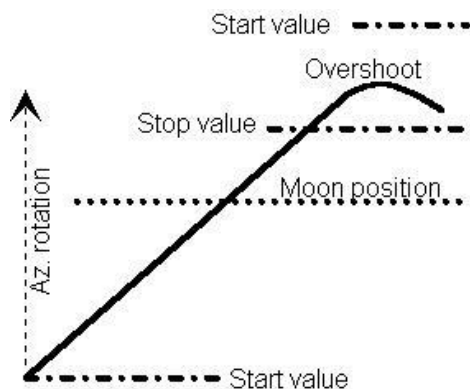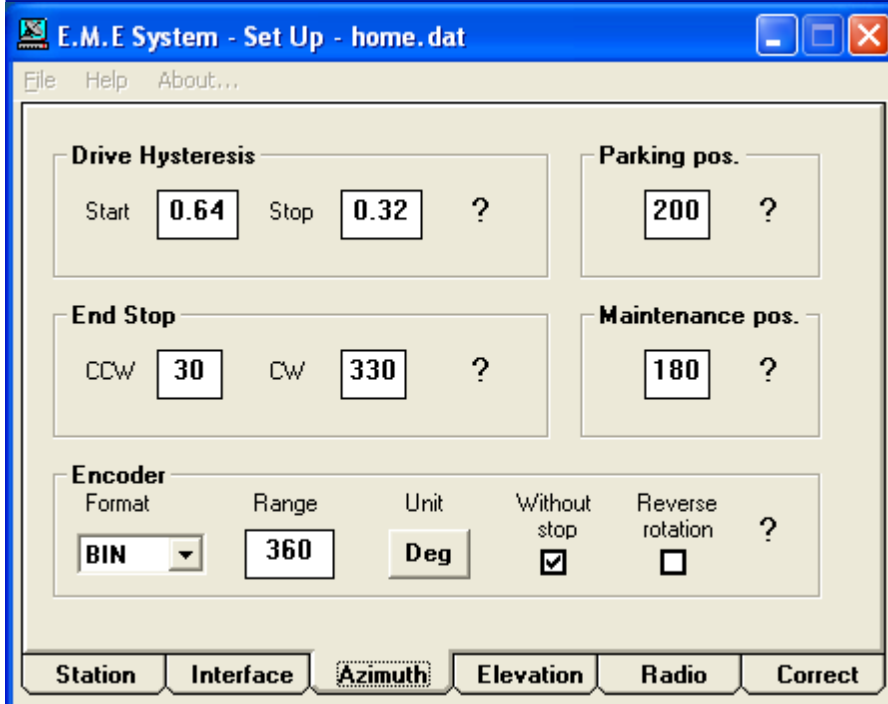### Setup MK-EHN board

Plug on the MK-EHN interface !

Open Com 1

Connected with interface version : 02.02a

Read Board Setup

Press the button to read the board setup.

Dialogue 16 / 16

Prog Id   55 99

USD encoders   ☐

16b parallel inputs   ☑

Use crash stops   ☐

Use speed control   ☐

Crash stops

Elev High   89

Elev Low   -10

Azim CCW   5

Azim CW   355

Analog functions

Azim Start   0

Azim Slow   0

Elev Start   0

Elev Slow   0

Heavy drive   0

Modify the values and write setup.
Then quit.

Write Board Setup   Quit

Station | Interface | Azimuth | Elevation | Radio | Correct

E.M.E System - Set Up - home.dat

File   Help   About...

Drive Hysteresis

Start   0.64   Stop   0.32   ?

Parking pos.

200   ?

End Stop

CCW   30   CW   330   ?

Maintenance pos.

180   ?

Encoder

Format	Range	Unit	Without stop	Reverse rotation	?
BIN ▼	360	Deg	☑	☐	

Station | Interface | Azimuth | Elevation | Radio | Correct

Start value ▬ ▪ ▬ ▪ ▬ ▪

Overshoot

Stop value ▬ ▪ ▬ ▪ ▬ ▪

Moon position ⋯⋯⋯⋯

Az. rotation

Start value ▬ ▪ ▬ ▪ ▬ ▪

Drive hysteresis and Tracking information

ANGULAR SETUP

- **Northern hemisphere azimuth setup**
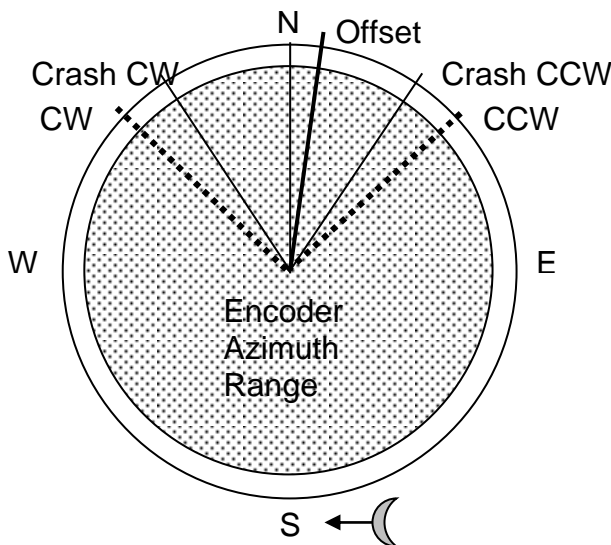
• **AZIMUTH Setup**		
Range: 360°		
Mode:	Binary, BCD or Gray	
Without stop:	No	Yes
Offset:	4.5° *	4.5° *
CCW:	45°	45°
CW :	315°	315°
• **MK-EHN Interface**		
Crash CCW:	30° **	30° **
Crash CW:	320° **	320° **

* used to set to zero the angle between the antenna and the encoder.
** the crash stops must be referenced to the zero position encoder

- **Southern hemisphere azimuth setup**
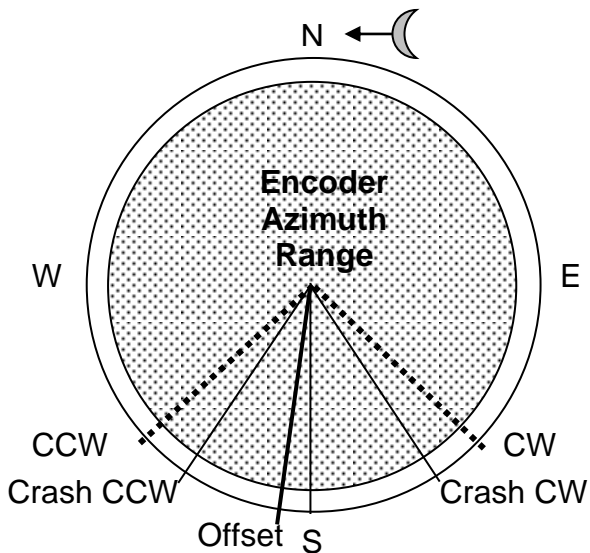
• **AZIMUTH Setup**		
Range: 360°		
Mode:	Binary, BCD or Gray	
Without stop:	No	Yes
Offset:	184.5° *	0.1°
CCW:	225°	225°
CW :	135°	135°
• **MK-EHN Interface**		
Crash CCW:	30° **	220° **
Crash CW:	320° **	140° **

* used to set to zero the angle between the antenna and the encoder.
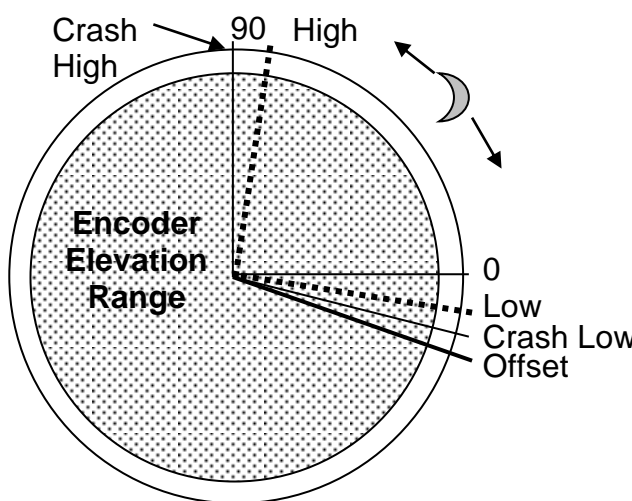** the crash stops must be referenced to the zero position encoder

- **Elevation setup**

• **ELEVATION Setup**		
Range: 360°		
Mode:	Binary, BCD or Gray	
Without stop:	No	Yes
Offset:	-15° *	0° *
High:	75°	75° *
Low:	-8°	-8° *
• **MK-EHN Interface**		
Crash High:	92° **	80° **
Crash Low:	2° **	-10° **

* used to set to zero the angle between the antenna and the encoder.
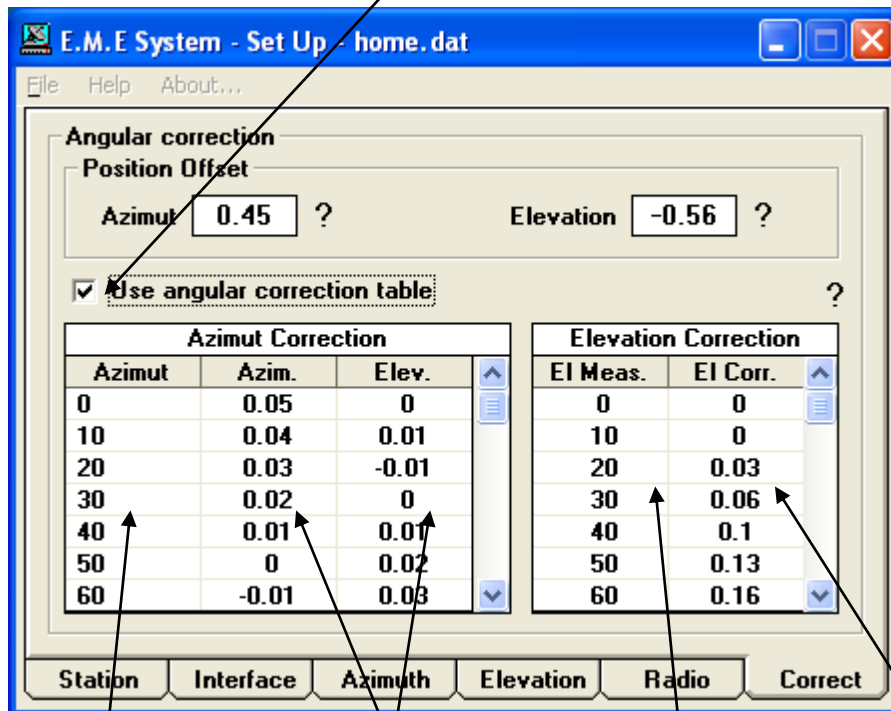** the crash stops must be referenced to the zero position encoder

EME Setup (Correct)

EME Setup creates automatically a ".tcv" file if the "Use angular.." box is checked (Ex : test_mk1.tcv / test_mk1.dat). Tracking will use this file automatically if the box is checked.

E.M.E System - Set Up - home.dat

File   Help   About...

Angular correction

Position Offset

Azimut [0.45]   ?   Elevation [-0.56]   ?

☑ Use angular correction table   ?

Azimut Correction				Elevation Correction		
Azimut	**Azim.**	**Elev.**		**El Meas.**	**El Corr.**	
0	0.05	0		0	0	
10	0.04	0.01		10	0	
20	0.03	-0.01		20	0.03	
30	0.02	0		30	0.06	
40	0.01	0.01		40	0.1	
50	0	0.02		50	0.13	
60	-0.01	0.03		60	0.16	

| Station | Interface | Azimuth | Elevation | Radio | Correct |

Azimut measurement (each 10 degrees)

Enter the correction for the azimut and elevation axes

Elevation measurement (each 10 degrees)

Enter the correction for the elevation axe

Antenna position with F1EHN or compatible interface

$True\_Az = Az\_Meas + Correct\_Az(Az\_Meas)$
$True\_Az = True\_Az + Offset\_Azim$

$True\_El = El\_Meas + Correct\_El(Az\_Meas) + Correct\_El(El\_Meas)$
$True\_El = True\_El + Offset\_Elev$

Source position with serial protocols or DDE interface

$True\_Az = Az\_Source + Correct\_Az(Az\_Source)$
$True\_Az = True\_Az + Offset\_Azim$

$True\_El = El\_Source + Correct\_El(Az\_Source) + Correct\_El(El\_Source)$
$True\_El = True\_El + Offset\_Elev$

TRACKING (1/3)

Enter Dxcc, locator, lat/lon coord., select it on the DXCC list or click on the worldmap

RF Freq. & Doppler shift

Antenna beamed to the moon on the sky temperature background
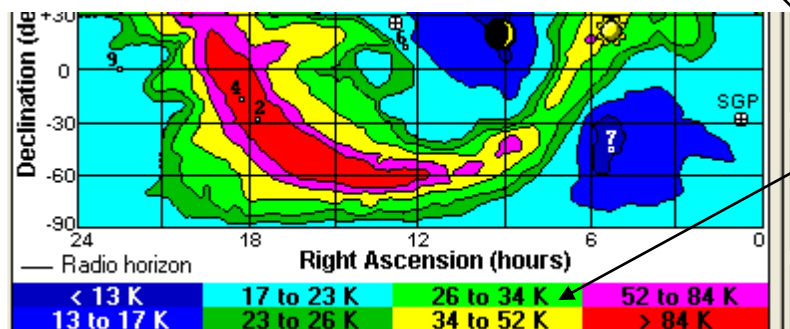
At 10 GHz, le Sky is totally cold (<5K).

At 432 MHz, Skymap display the scale of the sky temperature background

TRACKING (2/3)

3 main windows of Tracking :

Setup of RIG dialog

Save date, time & frequency of QSO

Sked warning

Sked List manager
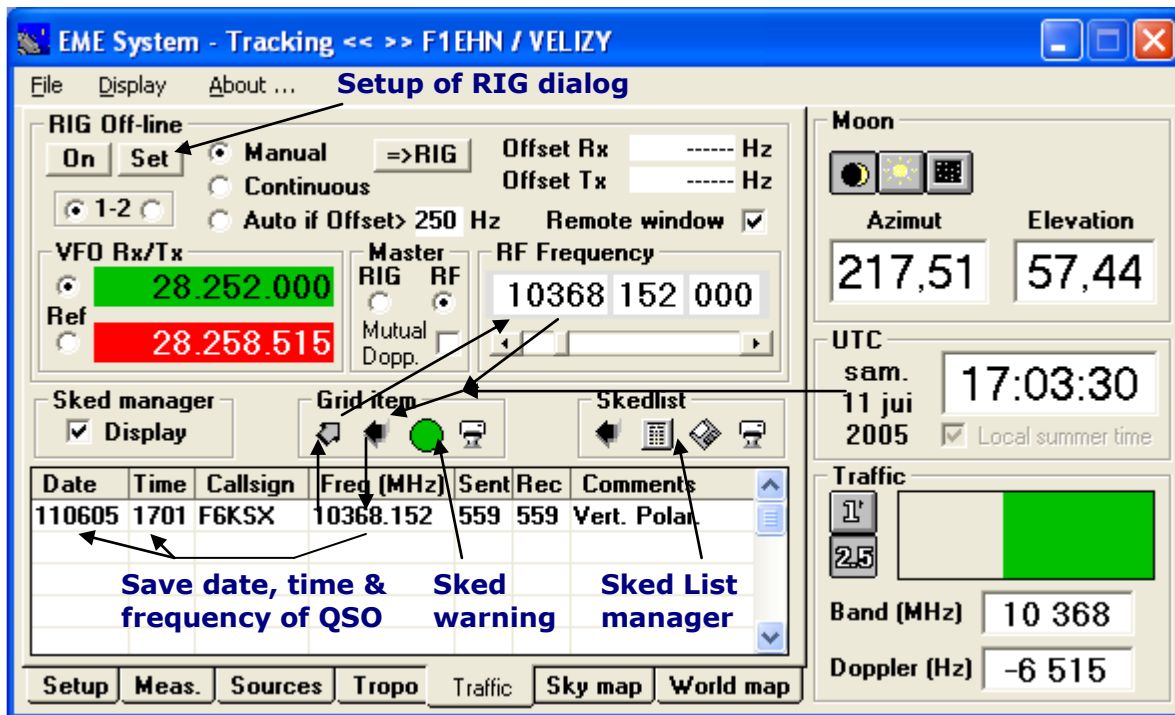
Remote RIG window (id. main RIG frame)

Displays the antenna and level measurements
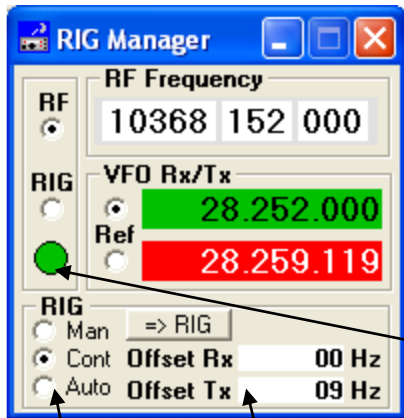
Rx Freq

Tx Freq

RIG link enabled

RIG management options

Offset between RIG & Tracking

Above, RF is master and Rx is the Doppler Reference
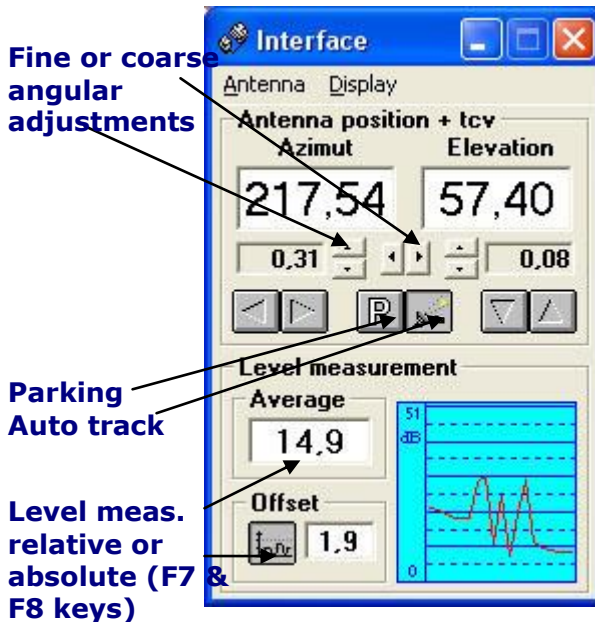
Fine or coarse angular adjustments

Parking Auto track

Level meas. relative or absolute (F7 & F8 keys)

TRACKING (3/3)

- Blue line = DX azimuth
- Red line = antenna azimuth

Press « Go to.. » to beam the antenna to the DX station

Check it to display the meas. tracking parameters

Cursor

Check it to use the Az correction versus Elev meas.
Real Azim aperture = Meas. Azim aperure * cos (Elevation)

PLANNER (1/2)
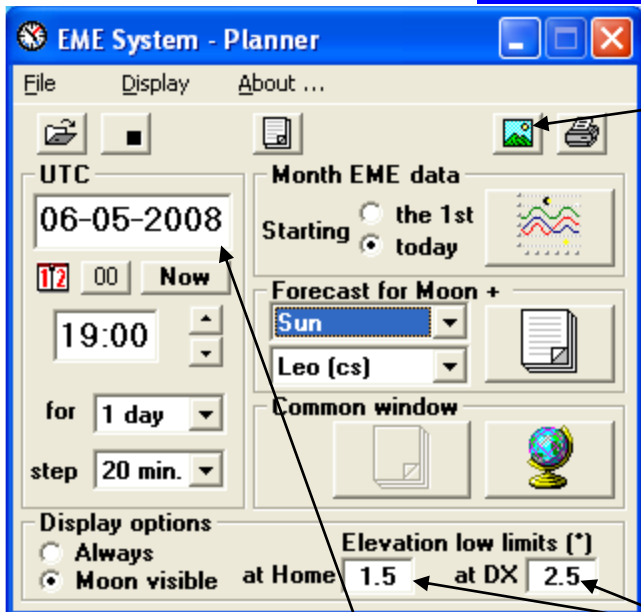
Clear screen : close all information display

Planner has 3 main modes :
- **Month EME data :**
  - Displays moon condition for EME
- **Forecast for a traffic period :**
  - Displays accurate information about EME condition for a defined period
- **Common Window :**
  - Displays information about a schedule with a DX station

1. Monthe EME data

Elevation limits at home and DX

EME System - Planner

File   Display   About …

UTC
06-05-2008
12 00 Now
19:00
for 1 day
step 20 min.

Display options
○ Always
● Moon visible

Month EME data
Starting ○ the 1st ● today

Forecast for Moon +
Sun
Leo (cs)

Common window

Elevation low limits (°)
at Home 1.5   at DX 2.5

Month EME data - F6KSX - 432 MHz

☑ Declination (°)
☑ Extra path loss/perigee [dB]

CS temp ref.
14 K

☑ TSyst degradation/CS [dB]
☑ Sky Temp degrad./CS [dB]

+30
0

23,1°
-1,8dB

-0,5dB
-3,0dB

Sun Offset
42,8°

-2.4
-30

-4.8
-4.8

25-26   2-3   9-10   16-17

19-06-2005   18-07-2005

3-07-2005
Cursor position

Start from …   19-06-2005   << Back   Next 30 days >>

Good EME conditions

Bad EME conditions

Bad EME conditions due to the sun offset

WE : direct link to UTC start

2. EME forecast

Sun 03-07-2005 from 14:00 to 23:40 UTC

F6KSX   Magny   Lat : 48,745 N Long : 2,045 E
Frequency : 432 MHz   Radio sky temp : 31 to 32 K
Extra loss/perigee : -1,9 dB   Moon Decl. : 25,6 to 26,0 deg

Time		Moon		Doppler (Hz)	Sun		Leo (cs)	
UTC	Local	Azim	Elev	Echo	Azim	Elev	Azim	Elev
14:00	15:00	271,39	33,08	-814	234,62	54,44	141,01	79,20
14:20	15:20	274,94	29,90	-836	240,72	51,65	161,28	80,82
14:40	15:40	278,40	26,74	-852	246,24	48,70	185,91	81,19
15:00	16:00	281,79	23,61	-863	251,29	45,62	209,01	80,18
15:20	16:20	285,13	20,52	-869	255,95	42,46	226,47	78,15

Time : direct link to UTC start (click in the line)

PLANNER (2/2)

3. Common window

Planner
About ...

Month EME data
Declinazion, Path loss, Sky temp, System temp...

Forecast for
Moon + Sun +
Leo (cs)

Common window

Elevation low limits (°)
at Home 1.5   at DX 2.5

Edit the common window list between the Home and DX stations

Moon --- Sun 03-07-2005 / 14:00

Select a Dxcc or click on the map

DX station
W4-AL Alabama
W4-AL Alabama
W4AD U.S.A. - VA
W4DEX U.S.A. - NC
W4-FL Florida
W4-GA Georgia
W4-KY Kentucky
W4-NC North Carolina
W4RDI U.S.A. - FL

Elev. 69,89   Distance 7 265
Azim. 104,46   Doppler 260
Polar Offset -68,3   Mutual Doppler -277

Sky map   World map

Elevation (Deg) 33,08   Traffic Frequency (MHz) 432
Azimuth (Deg) 271,39   Doppler Off. (Hz) -814

Sun 03-07-2005 from 14:00 to 23:40 UTC

Home station
F6KSX   Magny
Lat: 48,745 N   Long: 2,045 E

DX station
W4-AL Alabama
Lat: 32,354 N   Long: 86,292 W

Frequency : 432 MHz   Radio sky temp : 31 to 32 K
Extra loss/perigee : -1,9 dB   Moon Decl. : 25,6 to 26,0 deg

| | | Home | | Home - DX | | DX | |
Time	UTC	Local	Azim	Elev	Hz	Hz	Deg	Azim	Elev
	UTC	Local	Azim	Elev	Hz	Hz	Deg	Azim	Elev
	14:00	15:00	271,39	33,08	-814	-277	-68,3	104,46	69,89
	14:20	15:20	274,94	29,90	-836	-328	-72,4	110,77	73,86
	14:40	15:40	278,40	26,74	-852	-377	-79,9	120,26	77,62
	15:00	16:00	281,79	23,61	-863	-424	85,8	136,30	80,92
	15:20	16:20	285,13	20,52	-869	-469	59,1	164,60	83,05
	15:40	16:40	288,45	17,52	-869	-510	23,9	201,23	82,87
	16:00	17:00	291,78	14,57	-864	-550	-1,2	227,54	80,51
	16:20	17:20	295,12	11,68	-853	-585	-14,9	242,33	77,12
	16:40	17:40	298,49	8,88	-837	-618	-22,8	251,24	73,32
	17:00	18:00	301,91	6,19	-816	-647	-28,0	257,26	69,35
	17:20	18:20	305,38	3,64	-789	-671	-31,7	261,74	65,29

2005 / 14:00

5. Taurus A
NGP
8
SGP
7

Right Ascension (hours)
12   6   0

K   26 to 34 K   52 to 84 K
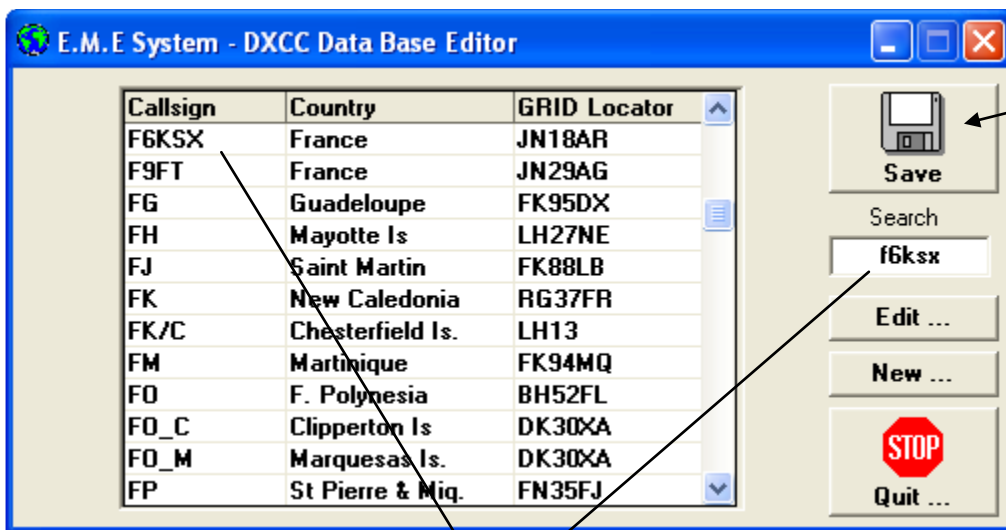K   34 to 52 K   > 84 K

Extra Loss   Range Km   Sky temp.
-1,90 dB   397 658   31 K
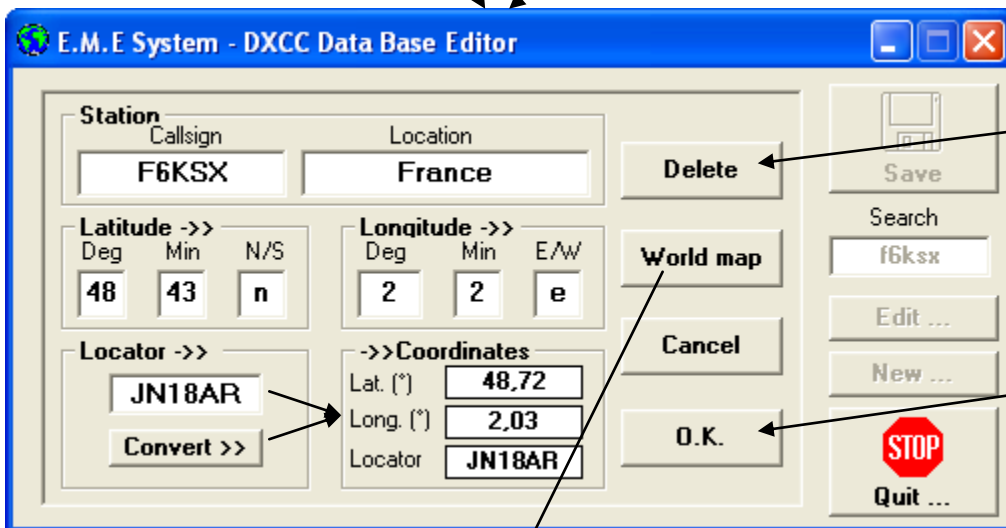
Sky map   World map

Traffic
Frequency (MHz) 432
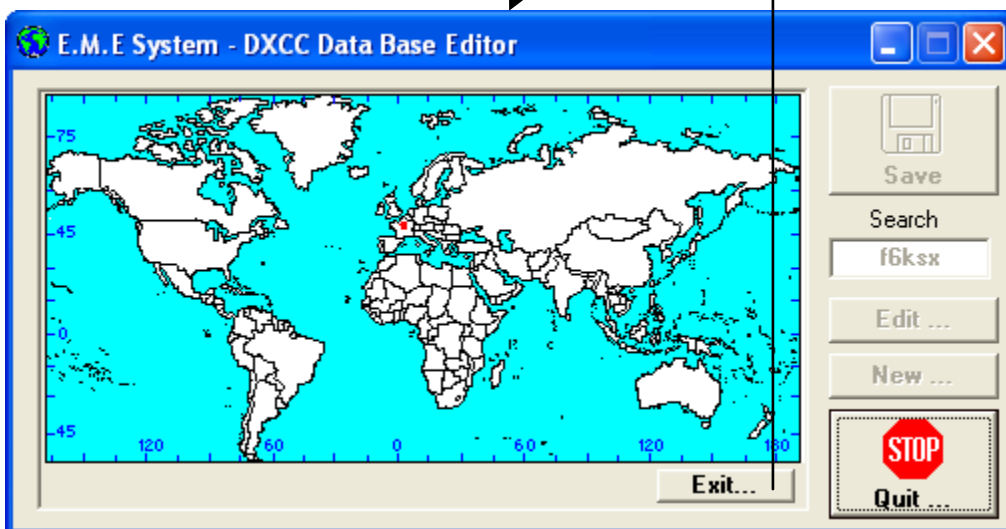Doppler Off. (Hz) -814

DXCC EDITOR

Save the data file on the hard disk

Delete the DXCC from the file

Save the DXCC in the data file

EME CALCULATOR

EME System - EME Calculator - home.dat

File   About

F1EHN

Tx Power Output	50 W	Rx to Feed Loss	0.3 dB
Tx to Feed Loss	0.8 dB	Rx Noise Figure	0.8 dB
Antenna Gain	47.5 dBi	Rx Bandwith	250 Hz

Default values   Print

Frequency 10368 MHz

DX station

Tx Power Output	100 W	Rx to Feed Loss	0.3 dB
Tx to Feed Loss	0.5 dB	Rx Noise Figure	0.8 dB
Antenna Gain	47.5 dBi	Rx Bandwith	500 Hz

Save DX info   Default values

Sky temp. 5 K   Path Loss -287.6 dB

Results @ Home station

System Noise	109.2 K
Moon Noise	2.02 dB
Total Noise	174.1 K

Perigee

Home   Signal -146.5 dBm   (S+N)/N 6.8 dB

DX   Signal -143.2 dBm   (S+N)/N 9.6 dB

Calculation

○ K
○ dBm/Hz

Results @ DX station

System Noise	109.2 K
Moon Noise	2.02 dB
Total Noise	174.1 K

DX   Signal -143.2 dBm   (S+N)/N 7 dB

Home   Signal -146.5 dBm   (S+N)/N 4.6 dB

Help   EME Budget   Noise Measurement

Reread the setup "dat" file

DX parameters = home parameters

Save the Dx parameters in emecalc.ini file

Reread the emecalc.ini file

Modifiable values

Calculated values

EME System - EME Calculator - home.dat

File   About

F1EHN

Tx Power Output	50 W	Rx to Feed Loss	0.3 dB
Tx to Feed Loss	0.8 dB	Rx Noise Figure	0.8 dB
Antenna Gain	47.5 dBi	Rx Bandwith	250 Hz

Default values   Print

Frequency 10368 MHz

Simulated antenna

Antenna temperature 26 K   Antenna aperture .66 Deg

Radiosources

Noise source
Average Quiet Sun

Cold sky (cs)
Cold sky (leo area)

Calculation

○ K
○ dBm/Hz

Results

Sky temp. (cs)	5 K
System Noise (cs)	109.2 K
Tot. radiated flux	326 Sfu
Tot. Radio Noise	4530.8 K
Y Factor	16.17 dB
G / Tsys	27.1 dB

Help   EME Budget   Noise Measurement

Modifiable values

Calculated values

Select a noise source

Select a cold source
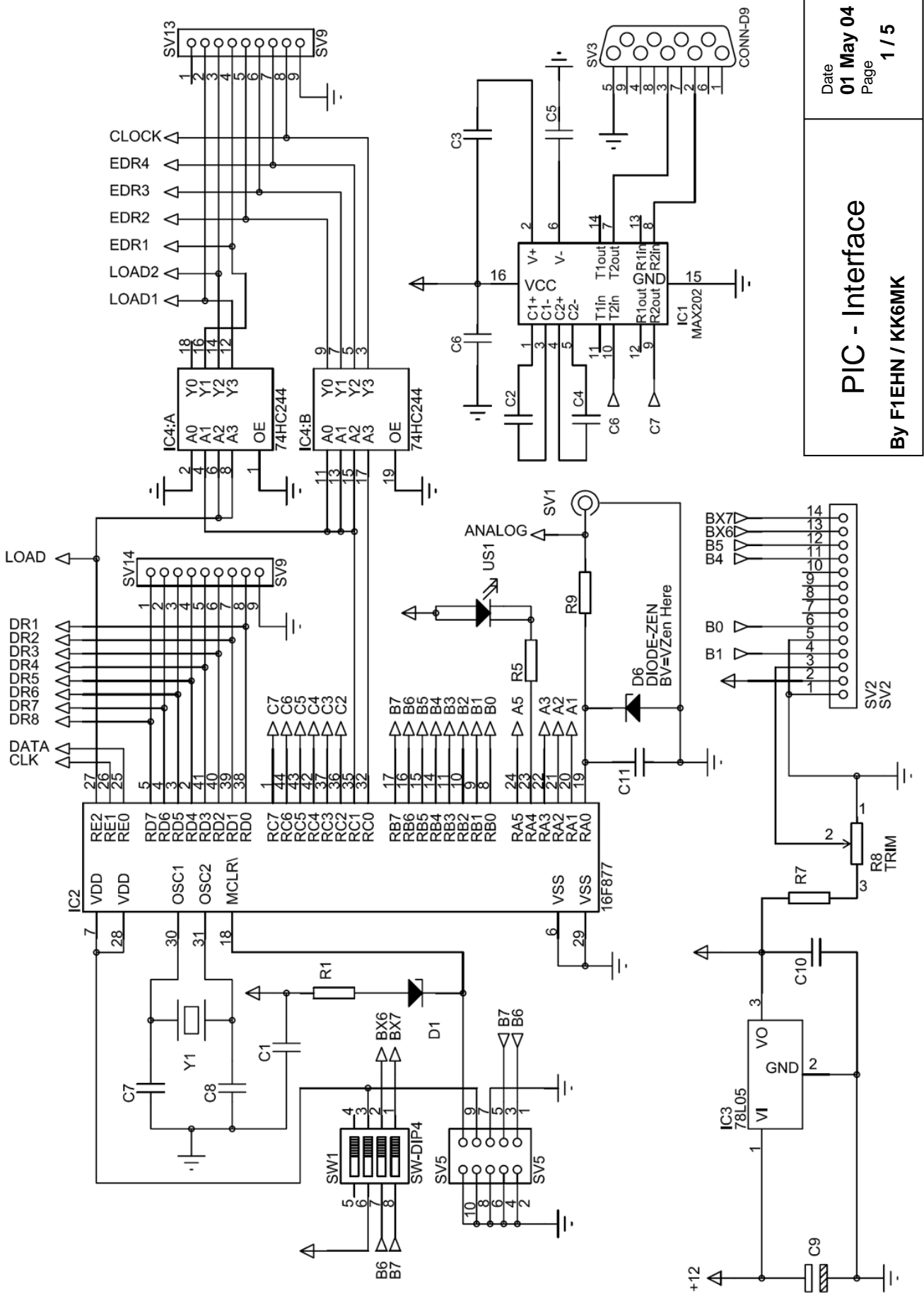
PIC - Interface

By F1EHN / KK6MK

Date	
01 May 04	
Page	**1 / 5**

Main function (2/2)
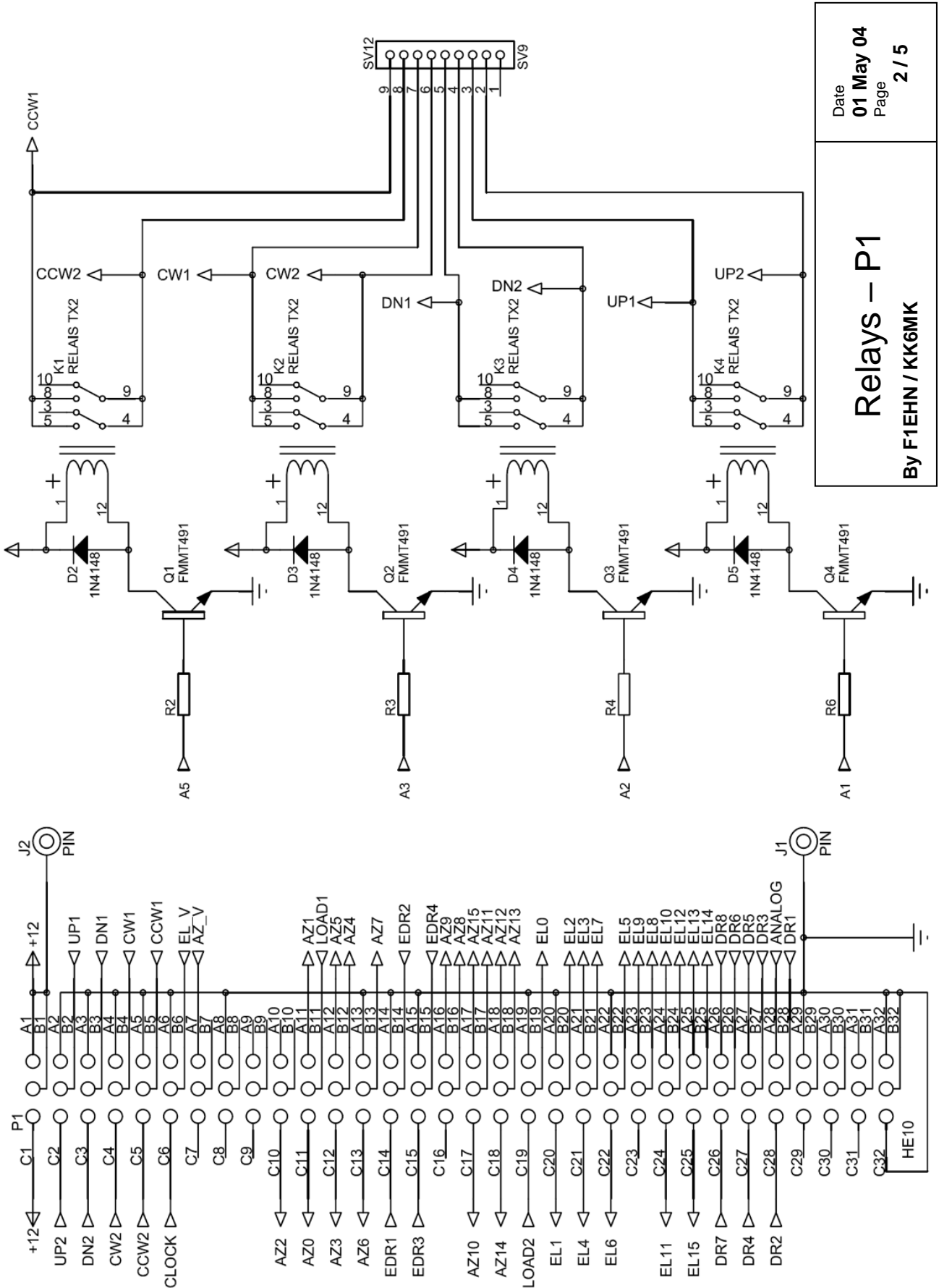
Date **01 May 04**
Page **2 / 5**

Relays – P1

By F1EHN / KK6MK

RS 485 option
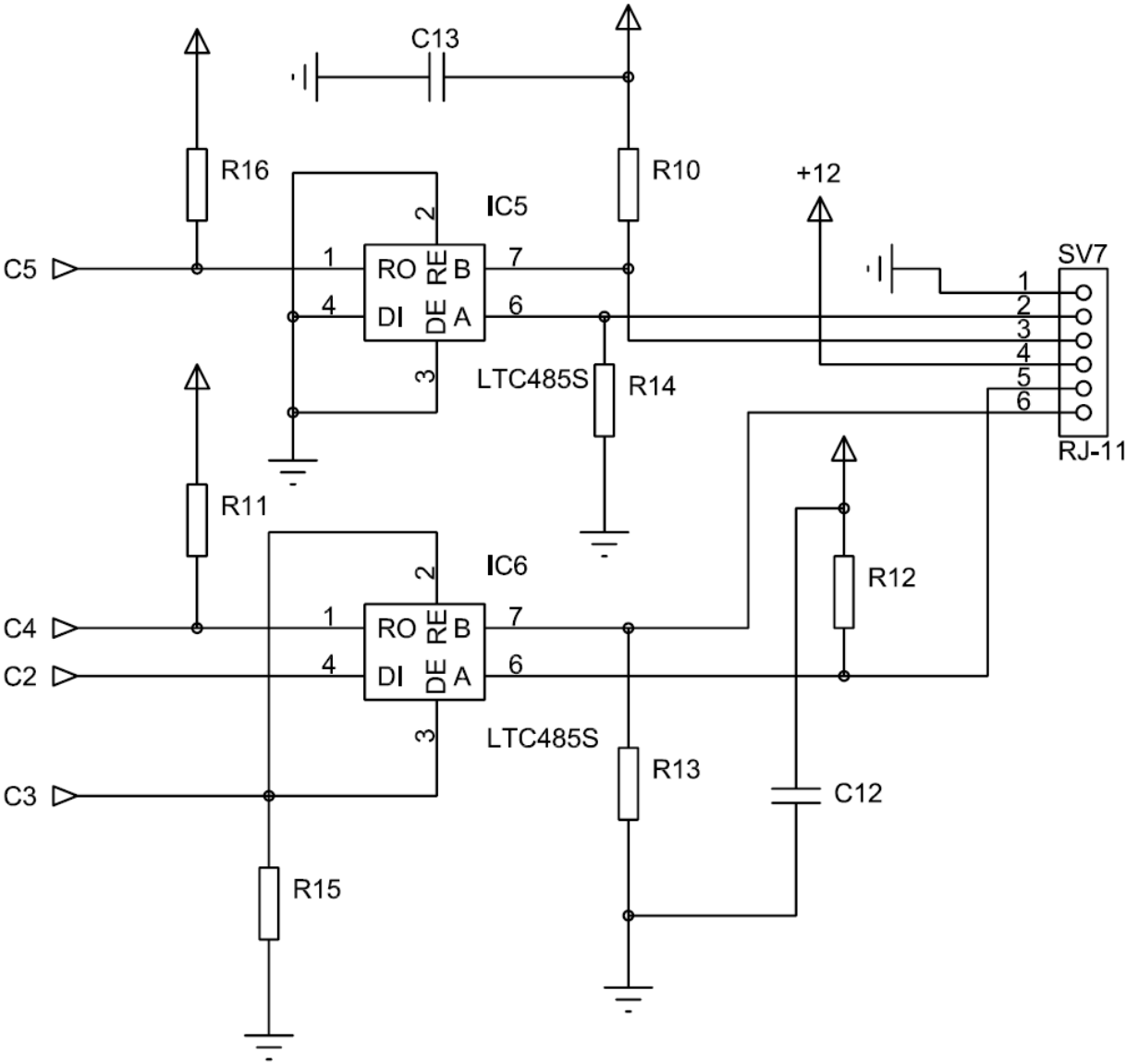
	Date
RS 485 Option	**01 May 04**
	Page
By F1EHN / KK6MK	**3 / 5**

16-bit // inputs option

	Date
16-bit // Option	**01 May 04**
	Page
By F1EHN / KK6MK	**4 / 5**

Interface 16-bit // inputs

Azimuth:

Signal Name	P1 connector	Binary format**	BCD format
Az 0 (LSB)	C11	0.005 deg	0.1 deg
Az 1	A11	0.011 deg	0.2 deg
Az 2	C10	0.022 deg	0.4 deg
Az 3	C12	0.044 deg	0.8 deg
Az 4	B12	0.088 deg	1 deg
Az 5	A12	0.176 deg	2 deg
Az 6	C13	0.351 deg	4 deg
Az 7	B13	0.703 deg	8 deg
Gnd	A14		
Az 8	B16	1.406 deg	10 deg
Az 9	A16	2.812 deg	20 deg
Az 10	C17	5.625 deg	40 deg
Az 11	B17	11.25 deg	80 deg
Az 12	A18	22.50 deg	100 deg
Az 13	B18	45.00 deg	200 deg
Az 14	C18	90.00 deg	to Gnd
Az 15 (MSB)	A17	180.0 deg	to Gnd
Gnd	A15		

Elevation :

Signal Name	P1 connector	Binary format **	BCD format
El 0 (LSB)	B19	0.005 deg	0.1 deg
El 1	C20	0.011 deg	0.2 deg
El 2	B20	0.022 deg	0.4 deg
El 3	A21	0.044 deg	0.8 deg
El 4	C21	0.088 deg	1 deg
El 5	B22	0.176 deg	2 deg
El 6	C22	0.351 deg	4 deg
El 7	B21	0.703 deg	8 deg
Gnd	A19		
El 8	B23	1.406 deg	10 deg
El 9	A23	2.812 deg	20 deg
El 10	A24	5.625 deg	40 deg
El 11	C24	11.25 deg	80 deg
El 12	B24	22.50 deg	100 deg
El 13	A25	45.00 deg	200 deg
El 14	B25	90.00 deg	to Gnd
El 15 (MSB)	C25	180.0 deg	to Gnd
Gnd	A22		

** *These values are indicated for a binary format used with a 360° encoder range.*

The unused bits must be connected to the ground (Gnd).

These inputs are also compatible with a Gray format.
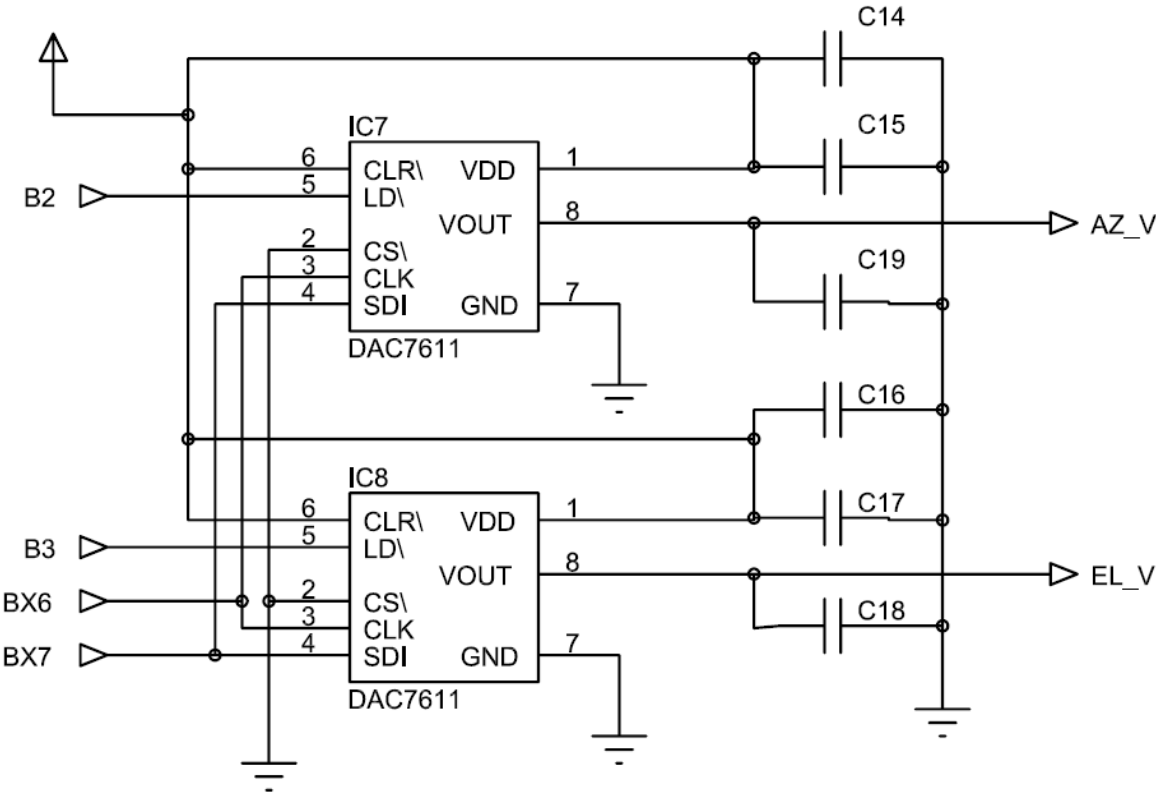
Speed control option

	Date
Speed control Option	**01 May 04**
	Page
By F1EHN / KK6MK	**5 / 5**

PCB / Wiring

16-bit //

RS485 *

Analog input (0/5v)

LED PC dialog

RS 232 to PC

Speed control

Optional display **
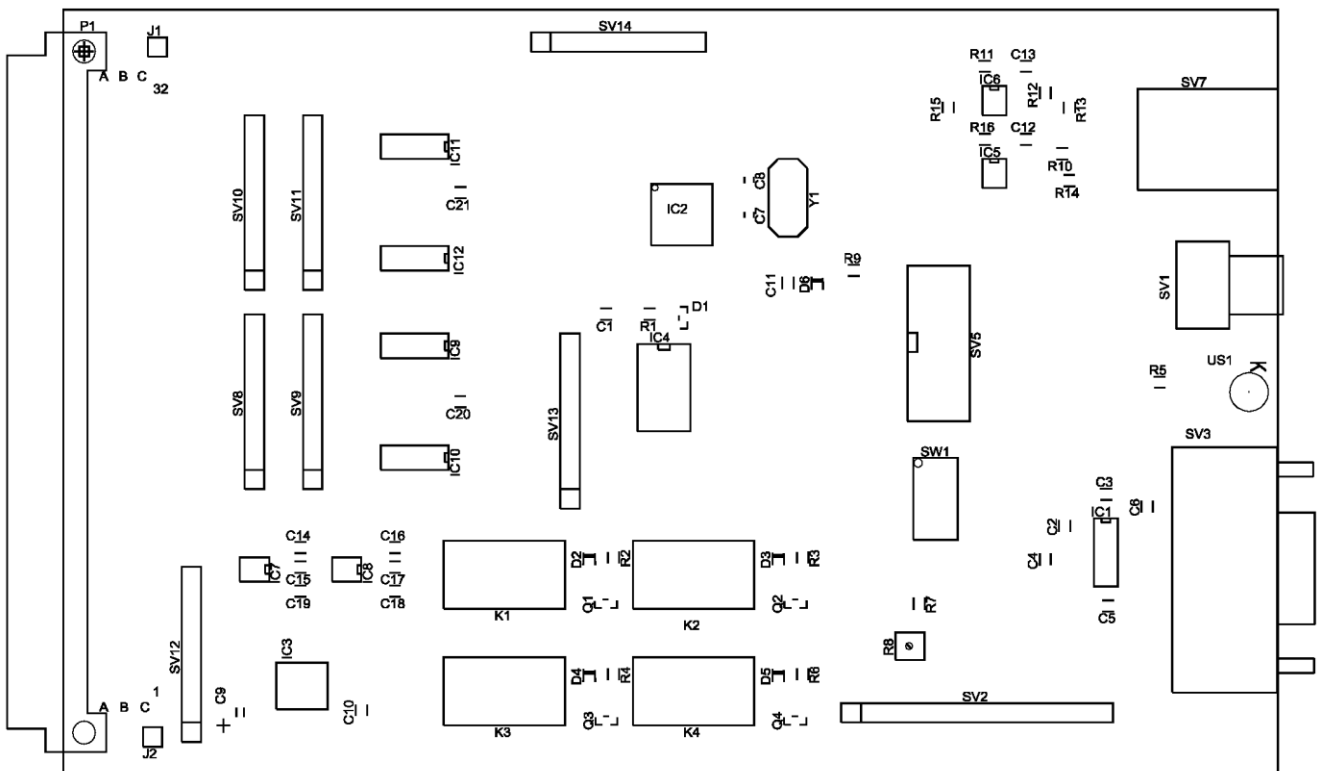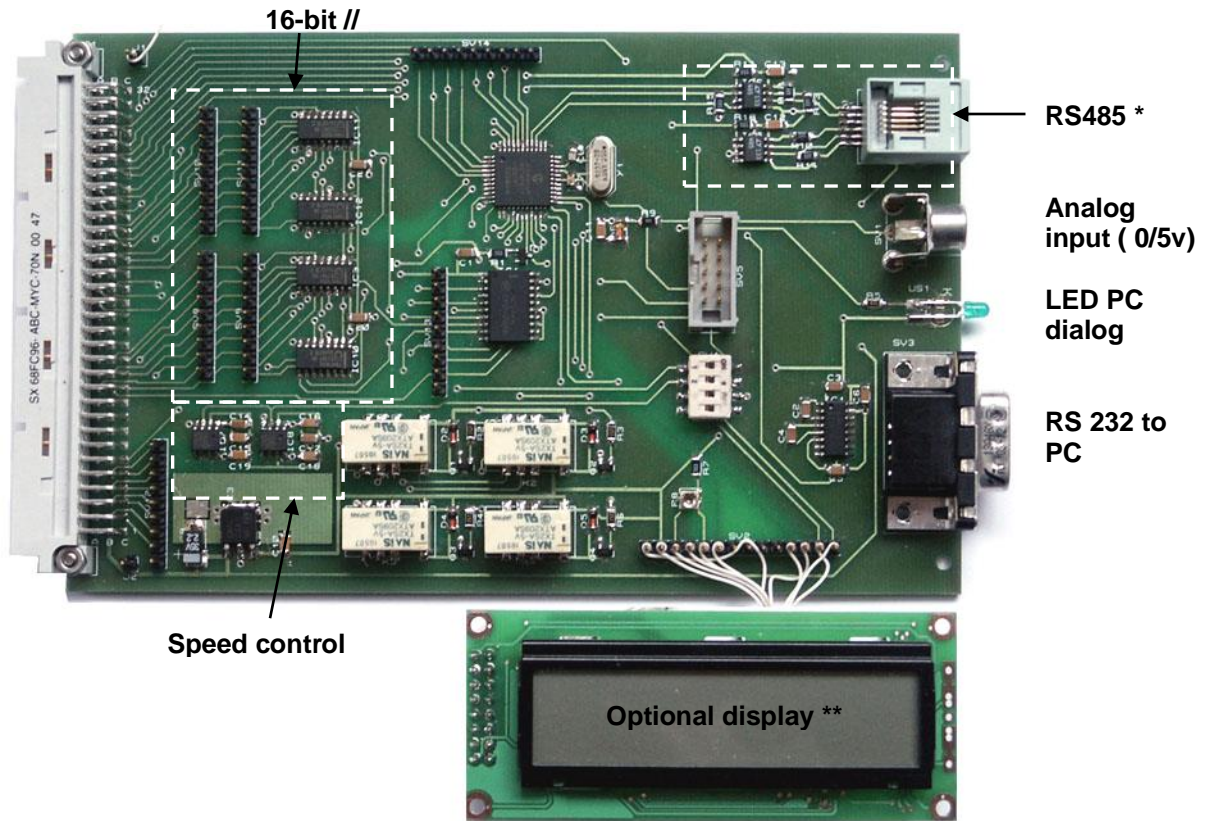
* If RS485 option is not implemented, R11 must be wired and pin 1 of IC5 set to Gnd (pin 2 of IC5).

** The LCD is wired pin to pin to SV2 (pins 7 to 10 are not used)

COMPONENTS LIST

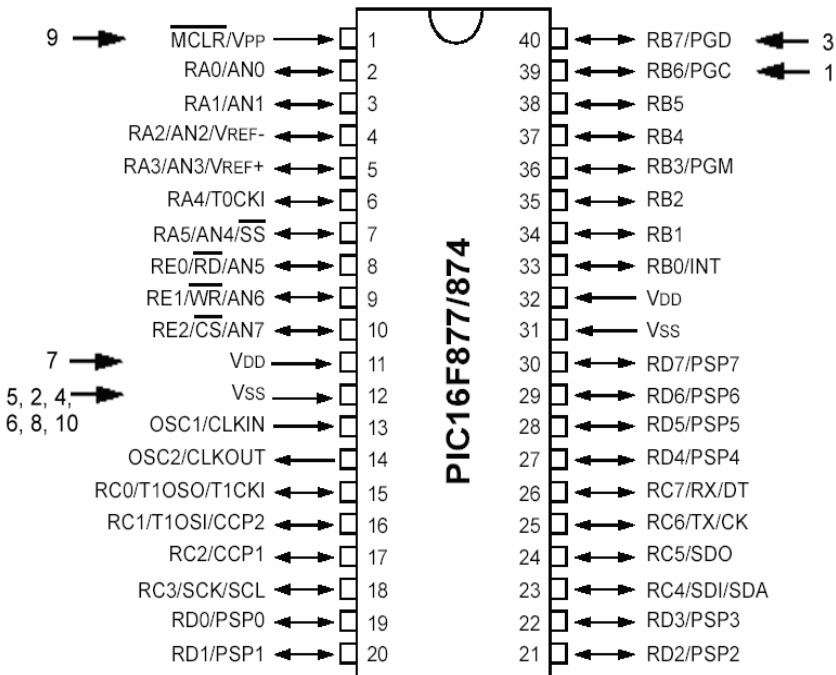| Type, Number	Value - Ref	Case	Quantity	Options	Ref RS
C1 to C6,C14,C17,C20,C21	0,1µF	1206	10		264-4179
C7,C8	12pF	0805	2		
C9	1µF	3216	1		334-9522
C10,C11,C12,C13,C15,C16 ->	10nF	1206	6		264-4141
-> C18,C19	Not wired				
D1	BAT54T1	SOT23	1		436-7818
D2,D3,D4,D5	LS4148	SOD80	4		443-3690
D6	BZV55C5V6	SOD80	1		446-8854
IC1	MAX202CSE	SO16L	1		225-8504
IC2	PIC16F877-04/PT	TQFP44	1		379-3165
IC3	UA78M05CDT	Dpack	1		189-0977
IC5, IC6	*LTC485s*	*SO08*	*2*	*	*371-504*
IC7, IC8	*DAC7611U*	*SO08*	*2*	*	*378-1910*
IC4	*74HC244D*	*SO20*	*1*		*113-0168*
IC9,IC10,IC11,IC12	*74HC165D*	*SO16*	*4*	*	*177-6629*
K1 à K4	TX2-SA-5V	SMT	4		217-2977
Q1 à Q4	FMMT491	SOT23	4		274-879
US1	Green LED	3mm	1		180-8502
Y1	3,6864 MHz	HC49/S	1		472-0168
R1,R7,R11,R15,R16	10 K	1206	5		
R2,R3,R4,R6	1,5K	1206	4		
R5	430	1206	1		
R9	100	1206	1		
R10,R12,R13,R14	330	1206	4		
R8	*2,5K*	*TRIM*	*1*	*	*188-5694*
P1	*DIN41612*	*96pins*	*1*	*	*160-2584*
SW1	IKN04	SMC	1		251-9152
J1, J2	Molex breakable	1 pin	2		see SV
SV1	Keystone 901	90° Jack	1		181-7720
SV2	Molex breakable	14 pins	1		see SV
SV3	SubD - 9P	PCB	1		495-9805
SV5	HE10-10P	PCB	1		461-742
SV7	RJ Modular 95001-6661	RJ 6pins	1		386-2722
SV8 to SV14	Molex breakable	9 pins	7		see SV
SV (Molex breakable type)	straight PCB pin header	HE14	1		423-2841
LCD	*DMC-16230 Optrex*	*16*2*	*1*	*	*214-3244*

Radiospares France: http://www.radiospares.fr
Radiospares Germany :   http://www.rsonline.de
Radiospares Global export : http://www.rs-export.com

ICP – Programming adaptor

	PIC16F877/874	
9 → $\overline{MCLR}$/VPP → 1	40	RB7/PGD ← 3
RA0/AN0 ↔ 2	39	RB6/PGC ← 1
RA1/AN1 ↔ 3	38	RB5
RA2/AN2/VREF- ↔ 4	37	RB4
RA3/AN3/VREF+ ↔ 5	36	RB3/PGM
RA4/T0CKI ↔ 6	35	RB2
RA5/AN4/$\overline{SS}$ ↔ 7	34	RB1
RE0/$\overline{RD}$/AN5 ↔ 8	33	RB0/INT
RE1/$\overline{WR}$/AN6 ↔ 9	32	VDD
RE2/$\overline{CS}$/AN7 ↔ 10	31	VSS
7 → VDD → 11	30	RD7/PSP7
5, 2, 4, → VSS → 12	29	RD6/PSP6
6, 8, 10 OSC1/CLKIN → 13	28	RD5/PSP5
OSC2/CLKOUT ← 14	27	RD4/PSP4
RC0/T1OSO/T1CKI ↔ 15	26	RC7/RX/DT
RC1/T1OSI/CCP2 ↔ 16	25	RC6/TX/CK
RC2/CCP1 ↔ 17	24	RC5/SDO
RC3/SCK/SCL ↔ 18	23	RC4/SDI/SDA
RD0/PSP0 ↔ 19	22	RD3/PSP3
RD1/PSP1 ↔ 20	21	RD2/PSP2

P1 & RS232 connectors

- **P1 : 96-pin main connector (optional)**

A	Signal	B	Signal	C	Signal
1	+12V	1	+12V	1	+12V
2	Gnd	2	Up(1) - motors	2	Up(2) - motors
3	Gnd	3	Dn(1) - motors	3	Dn(2) - motors
4	Gnd	4	Cw(1) - motors	4	Cw(2) - motors
5	Gnd	5	CCw(1) - motors	5	CCw(2) - motors
6	Gnd	6	El_V	6	Clock
7	Az_V	7	*Res.*	7	*Res.*
8	Gnd	8	*Res.*	8	*Res.*
9	*Res.*	9	*Res.*	9	*Res.*
10	*Res.*	10	*Res.*	10	Az2
11	Az1	11	Load(1)	11	Az0
12	Az5	12	Az4	12	Az3
13	Gnd	13	Az7	13	Az6
14	Gnd (Az)	14	EDR2	14	EDR1
15	Gnd (Az)	15	EDR4	15	EDR3
16	Az9	16	Az8	16	*Res.*
17	Az15	17	Az11	17	Az10
18	Az12	18	Az13	18	Az14
19	Gnd (El)	19	El0	19	Load(2)
20	Gnd	20	El2	20	El1
21	El3	21	El7	21	El4
22	Gnd (El)	22	El5	22	El6
23	El9	23	El8	23	*Res.*
24	El10	24	El12	24	El11
25	El13	25	El14	25	El15
26	Dr8 (Rx bus)	26	Dr6 (Rx bus)	26	Dr7 (Rx bus)
27	Dr5 (Rx bus)	27	Dr3 (Rx bus)	27	Dr4 (Rx bus)
28	Analog Sig.	28	Dr1 (Rx bus)	28	Dr2 (Rx bus)
29	Gnd (RxBus)	29	*Res.*	29	*Res.*
30	*Res.*	30	*Res.*	30	*Res.*
31	*Res.*	31	*Res.*	31	*Res.*
32	Gnd (M12V)	32	Gnd (M12V)	32	Gnd (M12V)

Res. = Reserved (N.C.)

- **RS 232 cable**

DB9	Signal		Signal	DB9
3	TD	⟶	TD	3
2	RD	⟵	RD	2
5	Gnd	⟷	Gnd	5
---	---		---	---

TIME DIAGRAM

DR
Data
Received

Clock
Synchro
Cycle

LSB
Azim
Read

MSB
Azim
Read

Signal
Polar
Read

LSB
Elev
Read

MSB
Elev
Read

LSB
Azim
Read

**Elev drive
Rx/Tx
Azim drive**

RS 232
to PC

| | LSB Azim | MSB Azim | Signal or Polar | LSB Elev | MSB Azim | | | | | LSB Azim |

RS 232
from PC
(RX Bux
dec. values)

| 150 | 160 | 128 | 149 | 224 | 192 | 5 to 127 | 5 to 127 | 0, 1, 2 3,4 16, 17, 18 | 150 | 160 |

Azim
Error

Elev
Error

Elev drive
Rx/Tx
Azim drive

RS 232 dialog cycle

VE1ALQ 16-bit encoder