80/22

EISCAT
TECHNICAL
NOTE

EISCAT Experiment Preparation Manual

by

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Foreword

The EISCAT Operating System is still being developed - and development will continue even when EISCAT is in operation. For example, the final form of the Common Programmes (see Appendix 1) will only be established after some months of operating experience. It is now likely that the merging of the data from the three sites (see 4.3.8) will take place immediately after an experiment, so that during the experiment itself, the data lines will be used for transferring 'quick-look' ionospheric data from site to site for the use of experimenters. The real-time display itself (see 3.8) is not finalised, but it will include profiles of electron density, possibly profiles of temperature, and a number of actual spectra observed at sample heights.

It follows that the time is not ready for a definitive manual, but the present working document has been produced as computer output in answer to requests from prospective users. We realise that in its present form the document has 'rough edges', and certain sections may need fuller explanation. However, we felt that for many people it would be useful in its present form, and in a year's time we will be in a better position to produce a definitive manual.

Corrigenda

Fig. 3.1 : change '933.5 MHz' to '(930.5+0.5xI) MHz where I = 1 to 11' and change '120.0 MHz' to '(123.0-0.5xI) or (117.0+0.5xI) MHz'

Page 3.4 : change 'SET-PATH <PATH CODE> (0 to 4... to 'SET-SIGNAL-PATH <PATH CODE> (0 to 3...

Page 4.6 : change '4196' to '4096'

Page 4.7 : change '1.86' to '1.85' and change 'Kiruna azimuth axis' to 'Kiruna elevation axis'

Page 5.5 : change 'TINTG' to 'TINT'.

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1. Introduction

This manual is intended as a guide for the preparation of experiments to be run on the EISCAT radar. It documents software available to run EISCAT experiments together with sufficient details about the EISCAT hardware to understand the software descriptions.

Section 2 is a basic guide to the use of EROS. Information on how to run EROS, details of the command syntax are explained and the philosophy of time synchronisation and of remote processing is described.

Section 3 concerns experiment programming. Details are given of the physical characteristics of the EISCAT hardware together with information on the software available for real-time control of the harware.

Section 4 is a description of the EROS program designed for the first common program. The experiment itself is described in section 4.1, Appendix 1 contains a listing of the EROS program used to control execution of the first common program. Section 4.3 contains detailed notes describing the individual instructions of the program of Appendix 1.

Sections 5 and 6 are included for reference.

Section 5 includes a list of all EROS commands currently available.

Section 6 is a programmers manual for the radar controller. Details of the radar controller hardware and the software available to write radar controller programs. Appendix 2 is a listing of the TARLAN-BASIC compiler used in the first common program.

2. The EROS users guide

2.1 Running an Experiment

It is envisaged that the majority of experiments will be run using EROS (EISCAT Real-Time Operating System). This section gives a brief summary of the command syntax of EROS and of the overall structure of the system.

Exeriments are developed as a series of EROS commands which are written into a file. The commands in this file are executed to perform the experiment. In the period preceding an experiment the commands are written into a file and the file copied to all sites.

2.2 Starting EROS

Firstly, the user must log-in to the NORD operating system. This is done by pressing the "escape" key on the keyboard of any terminal (note that on the Tektronix 4006 terminal the escape function is obtained by simultaneously depressing the keys "CTRL + SHIFT + K").

The SINTRAN-III command processor types out the date and time and a site identification message and asks for the user's identification by typing out:

ENTER

and waiting for a user name to be typed in (which in this case must be the user name "RT"). A protecting password is then asked for. It is requested by the question:

PASSWORD:

To which the user replies with the password protecting the account in question. The password for the user "RT" will be obtainable from the site manager of the site in question.

When the user name and password are correct, the SINTRAN-III operating system responds with the message:

OK

If either the user name or password are incorrect then the log-in procedure must be repeated.

The EROS system is now started by the command:

RT COMND

The user must then log out from the system by giving the command:

LOGOUT

The system responds with various messages terminating with the message:

--EXIT--

2.3 EROS Command Language Characteristics

When EROS is active the user gives commands to a program called the command processor (CP). The CP reads commands from either the command terminal (which can be any of the terminals connected to the NORD 10) or from a file. The command is checked for validity and the requested action is performed.

The syntax of commands given to the CP is similar to the command syntax used by the SINTRAN-III operating system.

In this guide, all commands are preceded by the characters "X:" which is the CP's prompt character (the meaning of the character "X" will be discussed in section 2.7).

During the time while EROS is active the "X:" is printed automatically and indicates that EROS is ready to accept a command.

A command consists firstly of a command name, followed by at least one blank followed by parameter words (which must be separated by commas) if necessary. Certain parameters may take a default value which will be used if the parameter word is omitted; this is done by giving two successive comma separators or by responding with a carriage return when a parameter is asked for.

Command names may be abbreviated by giving sufficient characters to distinguish them from other available command names. A special character (the "-" is used to separate words into two or more parts. Any part may be abbreviated as long as the abbreviation is unambiguous.

Consider as an example the commands "POINT-GEOGRAPHIC" and "PRINT-RECEIVER-PARAMETERS". The first command could be specified by typing any of the following:

X:<u>POINT-GEO</u>
X:<u>P-G</u>
OR
X:<u>PO</u>

(In the above, and in all the following examples of computer/human dialogues, the users's text is underlined)

The second command could be abbreviated by any of the following:

```
    X:PRINT
    X:PRINT-R
    X:P-REC
OR
    X:P--P
```

However, if only P is typed the CP will respond with the error message:

```
    AMBIGUOUS
```

Parameters are given by typing them in on the command line following the command name. The parameters must be separated by commas, a double comma instructs the system to provide a default value for the requested parameter. If a parameter is not supplied then EROS prints out a message asking for the missing parameter to be input.

Consider as an example one of the antenna pointing commands, having the syntax:

```
    POINT-AE <AZIMUTH>,<ELEVATION>
```

To point the antenna to (144.0,45.0) any of the following dialogues between the CP and user could take place:

```
    :POINT-AE 144.0,45.0
OR
    :POINT-AE
    :AZI:144.0
    :ELEV:45.0
OR
    :POINT-AE 144.
    :ELEV:45.0
```

In the above the words 'AZI:', and 'ELEV::' were printed out by the system because the user had not provided this information.

2.3.1 Preparation of Commands

Commands may freely contain comments after the '%' character. The start of the comment is signal by a '%' character and delimited by the end of line.

If a mistake is made while entering a line then the line can be corrected with one of the the following control characters:

```
CTRL-A      Deletes the last character
CTRL-Q      Deletes the last line
CTRL-R      Prints the current line
           (useful after you have typed a lot of CTRL-A's
           and forgotten where you are!)
CTRL-D      Repeats the last command
```

2.4 The HELP Command

The format is:

HELP <COMMAND>

The system responds by typing out a list of all commands which match (according to the abbreviation rules given in section 2.3) the command name specified.

For example:

HELP POINT

Will list all commands starting with the word POINT.

2.5 EROS Parameters

Provision is made for the use of parameters within EROS commands. Usually commands involve constants e.g.

POINT-AE 140.,45.

The required azimuth and elevation being constants. Whenever EROS expects a real parameter we can write "RNN" (where NN is a number from 01 - 10). The value of the NN'th real parameter will then be used in that command. Similarly the string "INN" is used for integer parameters.

The commands:

```
SET-REAL-PARAMETER
SET-INTEGER-PARAMETER
INCREMENT-REAL-PARAMETER
INCREMENT-INTEGER-PARAMETER
```

Are used to manipulate the parameter values. The current values of all parameters can be seen using the command "PRINT-PARAMETERS".

Example: write a program to do a simple elevation scan holding the antenna for 5 seconds with elevations varying in 1 degree steps between 10 and 40 degrees elevation.

```
SET-REAL-PARAMETER 1,9.
DO 31
     INCREMENT-REAL-PARAMETER 1,1.
     POINT-AE 100.,R01
     SYNC 5
ENDDO
```

Simpler is (of course):

```
PO-AE 100.,10.
DO 30
    SYNC 5
    MOVE-ELEV 1.
ENDDO
```

2.6 Synchronisation of Commands

All commands (with the exception of the "RUN-PROGRAM" and "SYNC" commands) are executed immediately. Certain commands, however, have to be obeyed at a precise time. This can be achieved by use of a "Virtual Clock Register" (VCR). A subset of EROS commands manipulate the value of the VCR and processes can be instructed to start/stop depending upon the value of the VCR. The commands manipulating the VCR are:

RUN-PROGRAM <FILE> <HR> <MIN> <SEC>

Purpose: sets <VCR>:=<hr><min><sec>. The program that executes commands in a file (the overseer) goes into a wait state and resumes execution at time <VCR>. When the current time of day equals <VCR> execution of the specified program begins.

Restrictions: program execution cannot be scheduled more than 24 hours in advance. Only one program can be scheduled at a time.

SYNC <time>

Purpose: sets <VCR>:=<VCR>+<time> (secs). Overseer goes into a wait state and resumes execution at time <VCR>.

START-RC <time>...

Purpose: loads the radar controller start time register with the start time <VCR>+<time> (secs.). When the current time of day equals the value loaded into the radar controller start time register the radar controller starts control of an experiment.

The commands "RUN-PROGRAM" and "SYNC" cause the overseer to go into a wait state and to resume execution at time <VCR>. In an error condition it may happen that this command is issued at some time after <VCR>. In this case the program resumes execution immediately and the message:

TIME SEQUENCE ERROR.... SKIPPING ON

Is printed. The user can, if so desired, stop the execution of the overseer if the error is serious.

Possible reasons for this error are:

1) Insufficient time has been allowed to do all the commands preceding the current command.
2) Power failure or hardware failure.

The importance of the "SYNC" command (and of this method of describing experiments) is that it allows process synchronisation between all sites even when the communications system is not running.

All the sites need to know is at what time a given program is to be run and what the program is.

Example: write a program to point the antennas to (lat,long,ht) = (69,23,110) at time 10.00. To start the radar controller with a given program at 10.20, to change the antenna direction at 10.30... Etc.

The following commands are written to a file:

```
POINT-LLH  69.,23.,110.
LOAD-RC 1200,,,,,
SYNC 1800
POINT-....
```

And the file scheduled for execution:

```
RUN-PROGRAM <FILE>,10,0,0
```

Note: units of "SYNC" and "LOAD-RC" are in seconds.

This program, if run at all sites, would synchronise the operations of all sites, irrespective of the state of the communications system.

2.7 Remote Processing

Built into EROS is the capability to issue commands to remote sites. This is done by first putting EROS in "REMOTE" mode and then entering the required commands, this is done by typing "REMOTE" follwed by one of the site codes:

"K"	for Kiruna
"T"	for Tromso
"S"	for Sodankyla
"R"	for both remote sites
"A"	for all sites

When in "REMOTE" mode all subsequent commands are sent to the remote site(s) concerned until the command "LOCAL" is issued.

At any time the site(s) being commanded can be seen from the EROS prompt character. This is of the form "X:" where "X" is one of the site codes given above.

Example: at Kiruna point the antennae to CAS-A, at Sodanklya to TAU-A and to print a message on the command terminals of all sites:

```
K:POINT-STAR CAS-A,,,,
K:REMOTE S
S:POINT-STAR TAU-A,,,,
S:LOCAL
K:REMOTE A
A:MESSAGE THIS IS A MESSAGE TO ALL SITES....
A:% ETC.
```

3. Experiment programming

3.1 General features

In order to program an experiment the user of EISCAT must be aware of the physical characteristics of the EISCAT hardware and of the software available for the control of the hardware. In the following sections the functional characteristics (from a software point of view) of the EISCAT system is described. This section describes in some detail the physical characteristics of the hardware that can be directly controlled from EROS.

We consider here how an experiment description in the form of a list of the physical settings of the apparatus necessary to perform an experiment is to be turned into a list of EROS commands. We shall do this by in turn considering the commands necessary to control the antennas, receivers, ADC's etc.

Throughout this document frequent reference will be made to various EROS commands. More details about the exact syntax of these commands, can be found in section 2.3. A complete list of the currently available commands is given in section 5.

3.2 Controlling the Antennae

The directions of the antennae can be specified in several different frames of reference, as follows (units degrees, Km.):

2.1 Local azimuth, elevation frame. Specify azimuth and elevation of local antenna.

2.2 3-D "point in space" frames. Point to a point in space where that point is described by:
1) Longitude, latitude and height
2) The azimuth, elevation of the Tromso antenna together with the range from the Tromso antenna to that point.
3) The azimuth, elevation of the Tromso antenna together with the geocentric height of that point.

2.3 As for 2) and 3) above but with respect to an arbitrary reference point (i.e. other than Tromso). The reference site is set by the command "CHANGE-REFERENCE-SITE".

2.4 Star coordinates (in this mode the antenna locks onto the star until the next pointing command is issued).

2.5 Magnetic frames of reference, as yet are not implemented.

Notes:

1) The antennae servo systems are not designed for continuous scanning but rather to point the antennae to fixed positions.
2) The time taken for antenna movements can be (crudely) calculated from the following:
   i) max. velocity of antenna c. 1.4 degrees/sec
   ii) max. Acceleration of antenna c. 1.4 Degrees/sec/sec

   To achieve maximum velocity the antenna accelerates for 1 second during which time it moves 0.7 degrees.

   e.g. To move 45 deg. Time = (45 - 2*.7)/1.4 + 2 = 31 sec. (approx)

3) The time taken for all three antennae to move to a common point is the maximum of individual antenna movement times.
4) Scan patterns requiring an individual antenna to scan through zenith are inadvisable because of the large angular changes in azimuth that are required (together with the accompanying changes to the polarisers that must be made. i.e. When receiving a linearly polarised signal then the sense of the polarisation would have to be rotated in the opposite direction to the antenna rotation).

   The EROS commands controlling the antenna are:

   POINT-AE
   POINT-REFERENCE-HEIGHT
   POINT-REFERENCE-RANGE
   POINT-GEOGRAPHIC
   POINT-STAR
   POINT-MAGNETIC-DIPOLE
   TRACE-STAR
   MOVE-HEIGHT
   MOVE-RANGE
   MOVE-AZI
   MOVE-ELEV
   MOVE-LAT
   MOVE-LONG

3.3 Controlling The Receivers

To control the receivers the user has to specify parameters in the front end of the receiver chain (fig 3.1.). In the receiver control unit the required channel selection must be made (fig 3.2.). In the individual receiver channels (fig 3.3.),(of which there are eight), filter and local oscillator settings must be set . These three stages are described below:

```
                                   -----------------
                                  \   ANTENNA      /
                                   \   HORN       /
                                    \------------/
                                     I (H) I (V)       933.5 MHZ
EXT -----X          I------I         I     I
           X---I ATTN I-----X-----X
NOISE ---X          I------I         I     I
                                     I     I
                                  I-----------I
                                  I   PARAMP  I
                                  I-----------I
                                    I       I
                                 I-------------I
                                 I  POLARISERS I
                                 I-------------I
                                   I         I
 OSCILLATOR                     I-----I   I-----I
1053.5 OR 813.5 MHZ. -----I MIX I---I MIX I
 (CALLED LO1)                   I-----I   I-----I
                                   I (L)     I (R)     120.0 MHZ
                                   I         I
```

FIG 3.1. UHF RECEIVER FRONT END (INSTALLED IN ANTENNA HORN)

After reception the horizontal (H) and vertical (V) components of the received signal are amplified first by a parametric amplifier and then by FET amplifiers. The resultant signals pass through a polariser where their relative amplitude and phase can be adjusted to any required value. After the polariser the two channels are called left and right (L and R). Before leaving the antenna hub room the signals are converted down to 120 MHz. by mixing with 1053.5 MHz or 813.5 MHz.

Optionally, noise generated by a standard noise source and attenuated by a precision programmable attenuator can be added to the signal. Provision also exists to add an external source which can be used in place of the standard noise source. Nominal values for the added noise are 30, 100 and 300 K. The actual values of the added noise will be available during experiments, these values being based on regular calibrations of the noise source and attenuators. During signal reception the attenuator is programmed for 0 K. which ensures that no noise is added to the signal.

Under EROS control selection of injected noise, polariser parameters (amplitude ratio L/R of -127 to + 127 dB in steps of quarter dB's - phase relation between L and R of 0 to 360 in degree steps), and sideband selection is possible. For the first stage of the receiver chain, the relevant EROS commands are:

```
SET-NOISE   <NOISE CODE> (0 = 0, 1 = 30K, 2 = 100K, 3 = 300K)
SET-LO1     <LO1   CODE> (0 = 1053.5 MHZ, 1 = 813.5 MHZ)
SET-POLARISER <PHASE CODE> <AMPLITUDE CODE>
```

```
         I                                        I
         I                                        I
     -----------                             -----------
     I (LEFT)  I          120 MHZ            I (RIGHT)  I
     -----------                             -----------
         I                                        I
     -----------                             -----------
     I  ATTN   I                             I  ATTN   I
     -----------                             -----------
         I                                        I
     -----------                             -----------
     I DIVIDER I                             I DIVIDER I
     -----------                             -----------
       I I I I                                 I I I I
       I I I I                                 I I I I
       1 2 3 4                                 1 2 3 4
  ----------------------------------------------------------
  I     . . . .  CHANNEL SWITCHING    . . . .              I
  ----------------------------------------------------------
   I     I     I     I     I     I     I     I
   I     I     I     I     I     I     I     I
```

FIG 3.2. CHANNEL SELECTION IN UHF RECEIVERS SECOND STAGE (CONTROL ROOM)

The two channels (L and R) described above are brought down to the EISCAT control room where eight receiver channels are available. A schematic of the receivers is illustrated in fig 3.2.

Options exist to switch the two input channels into the eight reception channels as follows:

L TO CHANNELS 1,2,3,4,5,6,7,8
L TO CHANNELS 1,2,3,4 AND R TO CHANNELS 5,6,7,8
R TO CHANNELS 1,2,3,4,5,6,7,8
R TO CHANNELS 1,2,3,4 AND L TO CHANNELS 1,2,3,4

The EROS commands affecting this stage of the receiver chain are:

SET-PATH <PATH CODE> (0 TO 4 GIVES THE PATHS IN THE ORDER LISTED ABOVE)
SET-SIGNAL-ATTENUATOR (SEE BELOW)

```
    I
    I
 ----------           ---------------------------
I  MIX    I----------I PROGRAMMABLE OSCILLATOR I  (CALLED LO2)
 ----------           ---------------------------
    I
 ----------
I ATTN.  I
 ----------
    I
 ----------
I FILTER I          (CALLED BP FILTER)
 ----------
    I
 ----------
I  AMP.  I
 ----------
    I
 ------------------------
I QUADRATURE DETECTOR I------- 30 MHZ
 ------------------------
    I            I
 ---------    ---------
I  AMP  I    I  AMP  I
 ---------    ---------
    I            I
 ----------   ----------
I FILTER I   I FILTER I          (CALLED LP FILTER)
 ----------   ----------
    I            I
 ------------------------
I     A/D CONVERTOR     I
 ------------------------
    I            I
 ------------------------
I     MATCHED FILTERS   I
 ------------------------
    I            I
    I            I        TO CORRELATOR BUFFER MEMORY
```

FIG 3.3. UHF RECEIVER SECOND STAGE (INSTALLED IN CONTROL ROOM)

Having switched the L and R channels to the final reception channels the resultant signal is mixed down to 30 MHz using a programmable oscillator, (referred to as the second local oscillator, "LO2") and thereafter filtered and attenuated before finally entering a quadrature detector where the signal in phase and in quadrature components (relative to a 30 MHz reference frequency) are extracted. After a final stage of filtering the signal is sampled using fast analogue to digital convertors (ADC's) and the resultant data processed by the correlator (having first been passed (if necessary) through a set of matched filters .

The available parameters in the receiver chain that can be set by EROS are the selection of channel switches, values of the first and second local oscillators, band and low pass filters and attenuators. Consideration of the data processing chain following the low pass filters will be deferred to sections 3.4 - 3.6.

The EROS commands available to set the final stage of the receivers are:

```
SET-CHANNEL-ATTENUATOR  (SEE BELOW)
SET-FILTER <CHANNEL> <FILTER CODE>
    CHANNEL = 1 TO 8
    FILTER CODE = 1 SETS  BP = 1.2 MHZ, LP = EMPTY
                = 2          = 1.2 MHZ,    =  25 KHZ.
                = 3          = 1.2 MHZ,    =  50 KHZ.
                = 4          = 8   MHZ,    = 100 KHZ.
                = 5          = 8   MHZ,    = EMPTY
                = 6          = 8   MHZ,    = 500 KHZ.
                = 7          = 30  MHZ,    = EMPTY
                = 8          = 30  MHZ,    =  25 KHZ.
                = 9          = 30  MHZ,    =  50 KHZ.
                = 10         = 30  MHZ,    = 100 KHZ.
                = 11         = 30  MHZ,    = EMPTY
                = 12         = 30  MHZ,    = 500 KHZ.

SET-LO2 <CHANNEL> <LO2 CODE>
    CHANNEL = 1 TO 8
    LO2 CODE DEPENDS UPON <CHANNEL>

    FOR CHANNELS 1 AND 5 (FLUKE)
        SET FREQUENCY = FREQUENCY IN HZ
    FOR ALL OTHER CHANNELS
        FREQUENCY =    74.5 + .5 * <LO2 CODE> (MHZ.)
                           (FOR   1.LE.<LO2 CODE>.LE. 61)
                  =   104.5 + .5 * <LO2 CODE> (MHZ.)
                           (FOR  62.LE.<LO2 CODE>.LE.122)
```

In setting the receivers attenuator settings have to be chosen to assure a suitable signal level at the input to the ADC's. This is done automatically by the EROS command:

```
SET-RECEIVERS
```

Optionally, the receiver attenuators can be set manually with the commands:

```
SET-SIGNAL-ATTENUATOR     <L OR R CHANNEL>,<DB 0 TO 63 DB>
SET-CHANNEL-ATTENUATOR  <CHANNEL NO.1..8>,<DB 0 TO 63 DB>
```

3.4 Programming The Radar Controller

The Radar Controller is programmed in a language called TARLAN (Transmitter And Receiver LANguage). To write a TARLAN program the user must first think out in detail the pulse pattern scheme needed for the intended experiment, work out the details of the reception schemes and convert all this to a TARLAN program. This process is complicated by restrictions imposed by the matched filters/correlator memory sizes and processing speed/ antenna movements etc.

During an experiment the radar controller (RC) is responsible for the following:

1) Sending START/STOP sampling signals to the ADC's
2) Sending START COMPUTE signal to the correlator (once every cycle).
3) Sending an end of integration signal to the correlator at the end of every integration period (this causes a data transfer to take place between the result memory of the correlator and the NORD 10 computer).
4) Switching RUN/BYPASS in the matched filters (to control Barker decoding (if used)).
5) Controlling noise injection into the system (0,30,100,300 K)
6) Sending signals to the transmitter to control pulse transmission.

Further information on programming the Radar Controller can be found in section 6.

It should be noted that while sampling is independant on all channles, noise injection or Barker decoding affect all channels simultaneously. This means, for example, that simultaneous reception of Barker and non barker coded pulses is problematic and that simultaneous reception of a signal on one channel and noise calibration on another channel is impossible.

3.5 Controlling the Correlator

During the execution of an experiment the correlator will execute one of a number of pre-prepared programs. These programs perform standard tasks such as computing the autocorrelation function for a single or multi-pulse experiment. All the correlator programs are complete to within a specification of experiment-dependant parameters which must be loaded into the correlator immediately before an experiment is performed.

For example, a standard correlator program exists to compute the ACF's corresponding to series of range gates for a single pulse experiment. The only parameters that are not defined in the program are the number of range gates in question, and the number of noise and calibration gates that are also to be included in the experiment. All that needs to be specified when the program is executed are the values for these parameters together with the name (or code number) of the standard program to be executed.

More information about the standard EISCAT correlator programs can be found in the document "EISCAT Correlator Standard Programs".

It should be noted at this stage that although the number of range gates etc. that can be specified at this stage is easy to change, corresponding changes have to be made in several other parts of the system. In particular, changes will have to be made to the Radar Controller program, as well as possible changes to the analogue to digital conversion rates required, the buffer memory start addresses, the tape dumping programs, the DMA controller programs etc.

Any change to a "standard" program will thus have to have been thought out in advance, and with considerable care. At a later date we hope to provide software to assist in the task of automatically configuring an experiment from a much more general specification .

The EROS commands used to load the correlator with a program and to specify parameters to the correlator are:

LOAD-CORRELATOR-SPECIAL-PROGRAM <FILE NAME>
LOAD-CORRELATOR-STANDARD-PROGRAM <PROGRAM NUMBER>
SET-CORRELATOR-APB <APB> <VALUE>
SET-CORRELATOR-APM <APM> <VALUE>
RUN-CORRELATOR

(APB, APM above refer to specific registers in the correlator - the APB registers contain instructions for the correlator buffer memory address processor, the APM registers contain instructions for the correlator result memory address processor)

3.6 Controlling the Flow of Data

During an experiment several different tasks may be running concurrently. Different programs will be calculating data that should be stored on tape, various hardware device will be storing data that eventually must be transferred to tape.

All data that is to be written to tape is channeled through a single program. This program is responsible for writing that data onto tape in a suitably blocked and formatted structure that will facilitate security of the data and ease of access at a later stage.

The "macro" format of the tapes corresponds to the ANSI standard for tape labelling (multi file volumes). The "micro" structure of the tape corresponds to the NORD 10's internal word structure, block sizes having been chosen for efficiency in the NORD 10 (though not necessarily for the most efficient usage of tape, i.e. highly packed tapes make for effective use of tape but are handled somewhat inefficiently by the NORD 10 operating system).

The starting and stopping of the programs in the system responsible for data collection and recording are entirely independant. For example, it is possible for the correlator to be periodically dumping data into the NORD 10 without the data necessarily being recorded on tape.

To start/stop transfer of data between the correlator result memory and the NORD 10 we use the following commands:

START/STOP-DUMPING-DATA

To control the recording of data on tape we use:

START/STOP-RECORDING-DATA

If the option "START-RECORDING-DATA" has been selected then every time a correlator data dump occurs this data is transferred to tape together with a so called "Parameter Block". This Parameter Block (128 words) contains a full list of all the current system parameters (for example current antennae settings, filter settings ADC rates etc.).

3.7 Additional Parameters

In addition to the major devices in the system mentioned above, various minor control commands have to be issued to other hardware components of the system. At present these are the Analogue to Digital Converters, (which have to be programmed with the required conversion rates), and the Correlator Buffer Memory (which requires the start address of each data channel to be specified). For programming the buffer memory section 6.7 should be consulted.

The following commands are responsible for these functions:

SET-ADC
SET-BUFFER-MEMORY

3.8 Data Display During an Experiment

During an experiment it will be possible to see in Real-Time various data that have just been recorded. Standard displays of the Ionospheric data will be available on a Tektronix Graphics Terminal.

In addition, special purpose user displays can be provided if requested.

The ability to do Real Time analysis of the data (as well as displaying the data) is allowed for. This is provided through a general purpose interface between the NORD 10 Real Time and background processors. The data taking will be performed by the Real Time system, while displays and analysis programs will be performed by background programs. This offers a high measure of security in the system. The display programs and analysis tasks will in no way interfere with the primary data taking. Any mistakes in these (display or analysis) programs will be trapped by the background processor and present no danger to the data collection system. The two systems will run concurrently with the data taking system having the higher priority.

4. A description of the EROS program for the first common program

4.1 Description of the First Common Program

The Tromso antenna beam is to be directed along the geomagnetic field line at about 250 km height. The transmitter will emit pulses suitable for the measurement of the autocorrelation function at all three receivers in the E-region and in the F1- and F2- regions. The height resolution in the E region will be 5 km, in the F1- region 10 km , and in the F2- region 20 km. The desired parameters derived from the ion spectrum are electron density, electron and ion temperatures, the ion composition, and the three components of the plasma velocity.

4.2 Format of the Experiment Description

From the description of the experiment above, the best set of instrumental settings has to be worked out. The overall description of the experiment tells what is to be measured, but not how to measure it.

From the specification we can calculate, from purely theoretical considerations, what are optimal pulse patterns, filter bandwidths etc. Once this has been done the theoretical requirements for the experiment (in terms of pulse lengths, sample rates etc.) is compared with the physical specifications of the EISCAT hardware (finite sample rates, 12% duty cycle of transmitter etc.).

Once an acceptable method of performing the experiment has been derived, the hardware requirements for the experiment are turned into a series of EROS commands. These commands are then typed into a file , together with necessary TARLAN programs etc. And the experiment is ready to run on the EISCAT system.

Individual commands comprising the EROS program can be tested by running EROS in the so called 'imperative' mode.

A complete listing of the EROS and TARLAN commands necessary for running CP1 (Common Program 1) at Tromso is given in Appendix 1. All the commands necessary to control the remote sites have not been included. In the following sections we describe in more detail what the individual commands of the EROS and TARLAN programs do and why they were chosen.

4.3 The EROS Program

The EROS program in Appendix 1, can be considered as a series of commands to the Tape Drive Controller Programs, to the Radar Controller etc. We consider each set of commands in turn in the order that they occure in the program.

When the system is initialised it is assumed that no tape has been "introduced" to the system. A blank tape is placed on the tape drive and the command:

MOUNT-TAPE <TAPE NUMBER>

issued. The system reads the first record of the tape. It is assumed at this stage that the tape has not been used before. The label of such a tape should be "EMPTY". If any other label is found then "MOUNT-TAPE" fails and a new tape must be tried. If the tape mounting procedure is successful the the label at the start of the tape is changed to "RAW", meaning raw data is to be written to this tape. Subsequent re-usage of this tape will result in a "MOUNT-TAPE" failure.

Once a tape has been succesfully mounted, execution of the EROS program is requested by the command:

RUN-PROGRAM CP1,<TIME>

The EROS program is assumed to reside in the file "CP1", execution of the program is scheduled to begin at <TIME>.

The program contained in the specified file (in this case the file "CP1") Will start to execute at the requested time. Its execution is traced below:

4.3.1) Commands to the Tape Controller Program

The first three commands of CP1 are:

```
START-EXPERIMENT HAGFORS,CP1,1
WRITEFILE FORMATS:DATA
SET-DATA-LENGTHS 1030,0
```

The first command causes a "Start Experiment" label to be written to tape. This label has contained within it the experimenters name "HAGFORS", the name of the experiment "CP1" and the Experiment number "1". Immediately following this label a file "NEWS:SYMB" will be written to the tape. This symbolic file will contain current news about the system.

The second command causes the file, in this case the file "FORMATS:DATA" to be written to tape in symbolic form. Any number of files can be written to tape in this manner.

The final command of this section tells the tape dump program the length of the expected correlator data dump and the length of "special data" expected. Special data here means any additional data put to tape that does not come from the correlator.

4.3.2) Commands to the Antennae Control Programs.

Initially we set the Tromso antenna to point up the direction of the geomagnetic field line through Tromso. This direction approximately corresponds to pointing the Tromso antenna with an azimuth of 183.2 degrees and elevation of 77.6 degrees. The remote antennae are pointed to intersect the Tromso beam at a height of 103.0 km.

The command to point the antennae should be issued relatively early in the list of commands because, at the start of the experiment, the positions of the antennae are unknown. Sufficient time must therefore be allowed for the antennas to reach the starting point for the experiment before measurements can proceed.

The above pointing requirement is effected by the command:

```
POINT-REFERENCE-HEIGHT 183.2,77.6,103.0
```

On execution of this command the antennae will start to move to the requested position.

4.3.3) Commands to the Receivers

Monostatic reception at Tromso is on two frequency channels. In the TARLAN programs describing the pulse and frequency reception patterns these two channels have been numbered 1 and 2. Channel 1 is for the multi-pulse experiment, channel 2 for the single pulse experiment.

The transmitted frequency (F) corresponding to channel number (I) is given by the expression:

$$F = 930.5 + 0.5 * I \text{ (MHz)}$$

This correspondence between physically transmitted frequency and logical channel number can easily be changed by changing the so called channel mapping tables in EROS. More details of this process can be found in section 6.

In the first stage of the receivers these frequencies are mixed with 1053.5 MHz (this is achieved by the EROS command 'SET-LO1 0'). Frequency 1 is 931.0 MHz, 2 is 931.5 MHz, after mixing with 1053.5 MHz intermediate frequencies of 122.5 and 122.5 MHz are obtained. These must be mixed down to 30 MHz to satisfy the requirements of the final stage of the receivers. This can be acheived by mixing with 152.5 MHz for the first channel and 152.0 MHz for the second channel. We could of course have equally well chosen 92.5 and 92.0 MHz, the choise is up to the user.

The second local oscillator (LO2) fixed channel oscillators frauencies (F) are given in terms of the commanded EROS code (J) by the relation:

```
F =  74.5 + 0.5 * J   (  1.LE.J.LE. 61)
  = 104.5 + 0.5 * J   ( 62.LE.J.LE.122)
```

Requiring that LO2 codes of 96 and 95 be set for reception channels one and two. All the above is a.hieved by the EROS commands:

```
SET-LO1 0
SET-LO2 1,96
SET-LO2 2,95
```

Other combinations of oscillator settings would be equally valid, i.e.

```
SET-LO1 0
SET-LO2 1,36
SET-LO2 2,35
```

Achieves the result by selecting a different sideband with the second local oscillator.

Filter settings of 25 KHz for channel 1 and 50 KHz for channel 2 are used in CP1. This is achieved by the EROS commands:

```
SET-FILTER 1,2
SET-FILTER 2,3
```

Finally the command:

```
RUN-RECEIVERS
```

Is issued to set the receiver attenuators so as to provide a suitable signal level at the inputs of the analogue to digital converters.

4.3.4) Commands to the Radar Controller

The Radar Controller (RC) is written in the language "TARLAN". Before running an experiment the appropriate TARLAN program must be written and run through the TARLAN compiler. During execution of an experiment the RC is loaded with the EROS command:

```
LOAD-RC <FILE> <TREL> <BUFFER> <TINT>
```

Where:

FILE	is the name of a file containing the object code of the previously compiled TARLAN program.
TREL	is the time (relative to the last set value of the EROS VCR register, see section 2.6 for a detailed explanation of the use of the VCR register) at which the RC program is to start.
BUFFER	is the buffer number of the program to be started in the RC.
TINT	is the required integration time (seconds).

The RC program can be started and stopped at will by use of the commands:

START-RC <TREL> <BUFFER> <TINT>

Where the parameters have the same meaning as for the command LOAD-RC. The command "STOP-RC" causes an immediate stop of the radar controller.

4.3.5) Commands to the Correlator

One of the EISCAT standard correlator programs is used to compute ACF's for single and multi pulse measurements of the type used in the first common program.

This program is complete and only needs supplying with certain variable parameters that describe, for example, the number of range gates required in the single and multi-pulse experiments, the number of points per range gate in the single pulse experiment, the positions of the pulses in the multi-pulse experiment etc.

These parameters are communicated to the correlator through the so called correlator APB and APM stacks. To set up these stacks to the correct values EROS commands of the following form are used:

SET-CORRELATOR-APB/APM <STACK POSITION> <VALUE>

The precise values of the actual APB and APM stacks used in CP1 is given in the listing of the file describing the CP1 experiment.

Having loaded the correlator parameter registers, we have to specify to the correlator which program is to be run, and finally tell the correlator to wait for start compute signals which will be sent by the radar controller. This is done with the commands:

LOAD-CORRELATOR-SPECIAL-PROGRAM <FILE>
RUN-CORRELATOR

The actual values set in the correlator APB and APM stacks for the control of the first common program can be found by consulting Appendix 1.

4.3.6) Programming the Buffer Memory

The Analogue to Digital Converters sample on channels 1 - 8 as commanded by the Radar Controller. Each sample sent by the ADC's to the buffer memory is tagged with 3 address bits which direct the internal flow of data within the buffer memory. At the start of each cycle the buffer memory is reset with the start address for data for each data channel. As data is received by the buffer memory the channel address bits carried along with the data are decoded and the data directed to the appropriate area in the buffer memory. In advance of running an experiment the start addresses of the different channel data in the buffer memory must be calculated (this can be done by an examination of the RC TARLAN program and knowledge of the ADC sampling rates on the different channels). In CP1 we program:

```
SET-BUFFER-MEMORY 1,0
SET-BUFFER-MEMORY 2,689
```

This means that data from channel 1 will start being recorded at correlator buffer memory location 0, and that data for channel 2 will start at location 689.

The correlator buffer memory will have room to store up to 4196 complex samples.

4.3.7) Programming the Analogue to Digital Convertors

The ADC's have to be programmed with the sample intervals required on each of the reception channels. The EROS command:

```
SET-ADC-RATE <CHANNEL> <RATE>
```

Sets the ADC rate on the specified channel (<RATE> here is in units of 0.1 microseconds) for example:

```
SET-ADC-RATE 1,300
```

Sets the ADC on channel 1 to provide one sample every 30 microseconds. Note that the actual controlling of when the samples are to be taken is the responsibility of the radar controller, also note that the initial delivery of ADC's only supports sample rates of less than 1 sample/10 microseconds. Within two years ADC's supporting 10 MHz sample rates should have been delivered.

4.3.8) Starting data collection

In CP1 data is recorded at three sites and the results spooled to Tromso where the data is stored on magnetic tape (copies are held at the remote sites in case this process fails). The command:

```
START-DUMPING-DATA
```

Enables the correlator DMA, while:

```
START-RECORDING-DATA
```

Instructs the system to transfer the data from the remote sites to Tromso. After the command START-DUMPING-DATA has been issued data will be transferred between the result memory of the correlator and the NORD 10 every time the radar controller sends a "start-data-transfer" interrupt to the correlator.

To start an experiment we must now activate the radar controller. The radar controller can be started and stopped with an appropriate combination of the commands:

LOAD-RC; START-RC; STOP-RC

See section 4.3.4 and 2.6 for more details.

The recording of data on magnetic tape is now activated by the command:

START-RECORDING-DATA

4.3.9) Remote sites scan cycles

At the remote sites the program is different to that at Tromso in that the following scan cycle is performed.

At 103 km measure for 80 secs.
At 110 km measure for 80 secs.
At 300 km measure for 80 secs.

We can calculate the antennae movement times as follows:
Firstly, we calculate the azimuth and elevation settings for the two remote sites at each of the three points where measurements will be taken. These are:

	Kiruna		Sodankyla	
Ht	Azimuth	Elevation	Azimuth	Elevation
103	343.75	29.06	309.63	13.29
110	343.58	30.91	309.44	14.29
300	337.89	63.82	304.03	37.33

To move from 103 km to 110 km the maximum angular change required in any antenna axis the 1.86 degree change required in Kiruna azimuth axis. This should take (1.86 - 1.4)/1.4 + 2.0 secs. (= 2.33 secs., see section 3.2 for explanation).

In the EROS system experiments (measurements) can only be started or stopped on a second boundary (this restriction is imposed by the radar controller). We therefore allow 3 seconds for the antennae movement between 103 and 110 km. Similar ly, between 110 and 300 km. we allow 25 secs. [(32.91 - 1.4)/1.4 + 2.0 = 24.51]; and between 300 and 103 km. we allow 26 secs. [(34.76 - 1.4)/1.4 + 2.0 = 25.83].

We require that the system measure with an integration time of 10 seconds at each of the spot heights (i.e. 8 data dumps/height). The whole scan cycle thus takes 80+3+80+25+80+26 = 294 seconds. It is also required that measurements only be taken when the antennae are in position and not while they are moving into position. This is achieved by judicious starting and stopping of the radar controller to ensure that measurements are only taken when the antennae are in position.

This scan is performed in an EROS 'DO - ENDDO ' loop. The actual loop is given in Appendix 1. Note that because this section of code only applies to the remote sites the entire code section is enclosed by 'REMOTE R - LOCAL' 'brackets'.

5. EROS commands

All EROS commands currently available are listed below. For each command the required parameters are described together with a short description of what the command does. The commands are ordered alphabetically with respect to the first character in the command name.

APPEND-AFTER-TAPE-FAIL

Used after a magnetic tape failure to position the tape at the correct point so that processing can continue.

BREAK

Used to break a "SYNC" condition in the overseer (see also explanation of the "SYNC" command).

COMPARE-CLOCKS

Perform a clock comparison on all three sites.

CLEAR-RECEIVERS

Clear receivers of all set parameters.

CHANGE-REFERENCE-SITE <SITE NAME> <LAT> <LONG> <HT>

Define a "reference site" to be used in subsequent pointing commands. Parameters: <SITE NAME>:= name of reference site; <LAT>:= latitude (deg.) of reference site <LONG>:= longitude(deg.) of reference site <HT>:= height (km) of reference site.

CHANGE-ANTENNA-OFFSET <MODEL NUMBER>

Define a calibration model to be used to correct antenna coordinates for pointing errors. Parameters: <MODEL NUMBER>:= see local site manager .

CHANGE-COMMAND-STREAM <CTERM> <ERRDEV>

Define physical streams for command terminal and error messages. Parameters: <CTERM>:= command stream; <ERRDEV>:= error stream. Note: (both CTERM and ERRDEV must be one of 1,9 or 34).

CHECK-BACKGROUND

Calculates the celestial coordinates of the point at which the antenna is currently looking prints the result (RA, DEC) on the command terminal.

DO <NTIMES>

Execute the block of statements enclosed between this statement and the next matching ENDDO statement the requested number of times. Parameters: <NTIMES> = no. of times to execute loop. Note: loops may be nested.

ENDDO

Delimit a DO group. (DO-ENDDO) groups can be nested to a limit of ten).

HELP <COMMAND>

Print list of all command names matching the specified name. Parameters: <COMMAND>:= command name abbreviation.

INCREMENT-INTEGER-PARAMETER <PARAMETER NO> <INCREMENT>

Increment one of the system integer parameters. Parameters: <PARAMETER NO>:= parameter number 1..10; <INCREMENT>:= integer.

INCREMENT-REAL-PARAMETER <PARAMETER NO> <INCREMENT>

As command "INCREMENT-INTEGER-PARAMETER" only for real parameters.

LOAD-CORRELATOR-STANDARD-PROGRAM <PROGRAM NO>

Load correlator with a standard program. Parameters: <PROGRAM NO> number of program.

LOADRC <PROGRAM> <START TIME> < BUFFER> <TINT>

Load radar controller and set ready to start execution at the given time. Parameters: <PROGRAM>:= program name; <START TIME>:= time at which RC program is to be started (units of seconds since the last "SYNC" command was given); <BUFFER>:= buffer number; <TINT>:= integration time (secs.).

LOCAL

Set EROS in local mode.

LOAD-CORRELATOR-SPECIAL-PROGRAM <PROGRAM>

Load correlator with a special program. Parameters: <PROGRAM> := file name of file containing correlator program.

MESSAGE <TEXT>

Display a message on the command terminal. Parameters: <TEXT>:= text of message.

MOUNT-TAPE <DRIVE> <TAPE NUMBER>

Mounts tape. Experimental data will be written onto this tape. Checks that the tape has the correct label. If not then the tape in unmounted. Parameters: <DRIVE>:= drive number (0,1); <TAPE NUMBER>:= expected tape number.

MOVE-LAT <DELTA-LATITUDE>

Move antenna from it's current latitude setting parameters: <DELTA-LATITUDE>:= change in latitude.

MOVE-LONG <DELTA-LONGITUDE>

As for command "MOVE-LAT" only for longitude.

MOVE-HT <DELTA-HEIGHT>

As for command "MOVE-LAT" only for height.

MOVE-RANGE <DELTA-RANGE>

As for command "MOVE-LAT" only for range.

MOVE-AZI <DELTA-AZI>

As for command "MOVE-LAT" only for azimuth.

MOVE-ELEV <DELTA-ELEVATION>
As for command "MOVE-LAT" only for elevation.

OFFSET-PPD <PPD DELAY>
Offset pulse propagation delay. The pulse propagation delay is the time taken for a pulse to go from Tromso up to the tristatic intersection region and back to the site concerned. The local time at the remote site concerned will be automatically locked to this delay. The delay can, however be offset by an amount <PPD DELAY>. Parameters: <PPD DELAY>:= time delay offset (units microseconds).

PRINT-RECEIVER-PARAMETERS
Prints receiver parameters.

POINT-AE <AZI> <ELEV>
Point antenna in local azimuth elevation frame. Parameters: <AZI>:= azimuth (degrees); <ELEV>:= elevation (degrees).

POINT-REFERENCE-HEIGHT <AZI> <ELEV> <HT>
Point antenna in (azi,elev,ht) frame. Parameters: <AZI> := azimuth (degrees); <ELEV>:= elevation (degrees);<HT>:= height (km.).

PRINT-PARAMETERS
Print integer and real parameter arrays.

PRINT-RC-PARAMETERS
Print radar controller parameters.

PRINT-CORRELATOR-PARAMETERS
Print correlator parameters

POINT-GEOGRAPHIC <LAT> <LONG> <HT>
Point antenna in (lat,long,height) frame. Parameters: <LAT>:= latitude (degrees); (degrees); <HT> := height (km.).

POINT-REFERENCE-RANGE <AZI> <ELEV> <RANGE>
Points antenna in (azi,elev,range) frame. Parameters: <AZI> := azimuth (degrees); <ELEV> := elevation (degrees); <RANGE> := range (km.).

POINT-STAR <NAME> <UT> <RA> <DEC>
Points the antenna at a star. Parameters: <NAME> := star name; <UT> := universal time (hr.mmss); <RA> := right ascension (degrees); <DEC> := declination (degrees).

POINT-MAGNETIC-DIPOLE
Not yet implemented.

PRINT-TAPE-STATUS
Print current tape status. (Length of tape left , number of data blocks written etc.).

RUN-CORRELATOR
Starts correlator.

REMOTE <SITE>
set EROS in remote mode. From now on until "LOCAL" mode is selected all commands issued will go to the site(s) specified in the <SITE> parameter. Parameters: <SITE> := site (one of: K for Kiruna, S for Sodankyla, T for Tromso, R for remote sites, A for all sites)

RETURN-TO-SINTRANIII
Return from EROS to SINTRAN III.

RUN-PROGRAM <PROGRAM> <HR> <MIN> <SEC>
Start execution of a set of EROS commands stored in a file. Parameters: <PROGRAM> := file name of file containing commands; <HR> := start time (hr); (if -1 program starts in 10 seconds). <MIN> := start time (min); <SEC> := start time (sec).

READ-ANTENNA
Reads the current antenna position.

RFINJECT-ON
Turns on RF injection in the antenna horn.

RFINJECT-OFF
Turns off RF injection in the antenna horn. Default value is "RFINJECT-OFF".

STOP-OVERSEER
Stops execution of a set of commands stored in a file.

SET-REAL-PARAMETER <PARAMETER NO> <VALUE>
Set one of the system real parameters parameters: <PARAMETER NO> := parameter number (1..10); <VALUE> := real.

SET-FILTER <CHANNEL> <VALUE>
Set filter value to required value parameters: <CHANNEL> := channel no (1 to 8); <FILTER VALUE> := (code 1 to 12). For meaning of code see information at local site.

SET-ADCRATE <CHANNEL> <ADC RATE>
Set sampling rate on a given channel. Parameters: <CHANNEL> := channel no (1 to 8); <ADC RATE> := micro seconds * 10.

SET-BUFFER-MEMORY <CHANNEL> <STARTADDRESS>
Sets the start address for a given channel in the buffer memory. Parameters: <CHANNEL> := channel no. (1 to 8); <START ADDRESS> := integer location in buffer memory where the data for the selected channel will start to be stored.

SYNC <TIME INCREMENT>
Sets a time break point by which timeall processes must be completed. By this means all remote sites can be kept in phase. Parameters: <TIME INCREMENT> := incremental time (seconds) since last "SYNC" command or "RUNPROGRAM" or "STARTRC" command was given.

STOP-RC
Immediate stop of radar controller.

START-RC <TINC> <BUFFER> <TINTG>
Same as command "LOAD-RADAR-CONTROLLER" except that the parameter <PROGRAM> is not supplied.

SET-NOISE <NOISE VALUE>
Injects noise of a known temperature into the system. Parameters : <NOISE> := noise value (must be one of 0,30,100 or 300 deg. K) these temperatures are nominal, to find actual values consult site manager.

START-RECORDING-DATA
Starts recording data on tape (or communication line).

STOP-RECORDING-DATA
Stops recording data on tape (or communications).

START-EXPERIMENT <EXPT NAME> <EXPT TITLE> <EXPT NO>
Writes a header onto the data tape (before this command has been given no data can be written to tape). Parameters: <EXPT NAME> := experimenter's name; <EXPT TITLE> := experiment title; <EXPT NUMBER> := experiment number.

START-DUMPING-DATA
Start responding to the interrupt given whenever a correlator DMA dump occurs.

STOP-DUMPING-DATA
Stop responding to correlator data received interrupt.

START-GRABBING-DATA <NO. AREAS> <L1,L2>,...
Start the data grabber program. When activated this program extracts a subset of the data present in the system (called a data partition) and puts it into a buffer where it can be processed by an analysis or display program. Parameters: <NO. AREAS> := number of data partitions; <L1,L2> := upper and lower bounds of data partitions to be examined. The number of such partitions is given by the parameter <NO. AREAS >.

STOP-GRABBING-DATA
Stops the process activated by the "START-GRABBING-DATA" command.

SET-INTEGER-PARAMETER <PARAMETER NUMBER> <VALUE>
Sets system integer parameter. As for command "SET-REAL-PARAMETER", only for integers.

SET-LO1 <SIDEBAND>
Sets first local oscillator: <SIDEBAND> := 1 for 813.5 MHz, 0 for 1053.5 MHz.

SET-SIGNAL-PATH <PATH>
Defines the signal paths in the receivers parameters: <PATH> := 0 = X => 5,6,7,8; Y => 1,2,3,4
1 = Y => 1,2,3,4,5,6,7,8; 2 = X => 1,2,3,4,5,6,7,8;
3 = X => 1,2,3,4; Y -> 5,6,7,8;

SET-SIGNAL-ATTENUATOR <SIGNAL> <ATTN>
Sets the upper signal attenuator parameters: <SIGNAL> := 0 for channel X ; 1 for channel Y ; <ATTN> := attenuation (0 - 63 db)

SET-LO2 <CHANNEL> <OSCILLATOR VALUE>
Sets the second local oscillators parameters: <CHANNEL> := channel number (1-8) ; <OSCILLATOR VALUE> := real.

SET-CHANNEL-ATTENUATOR <CHANNEL> <ATTN>
Sets the channel attenuators parameters: <CHANNEL> := channel number (1-8) ; <ATTN> := attenuation (0 -63db).

SET-CORRELATOR-APB <APB> <VALUE>
Sets the correlator APB register to the given value. Parameters: <APB> := APB register address (1-12); <VALUE>:= value to be loaded to APB register.

SET-CORRELATOR-APM <APM> <VALUE>
As for command "SET-CORRELATOR-APB" only for APM registers.

SET-CORRELATOR-DATAIO <VALUE>
Sets the correlator DATAIO register to the given value. Parameters: <VALUE> := value (integer) to be loaded to the correlator DATAIO register.

SET-CORRELATOR-BASEADDR <VALUE>
Sets the correlator BASEADDR register to the given value. Parameters: <VALUE> := value (integer) to be loaded to the correlator BASEADDR register.

SET-POLARISER <PHASE> <AMP>
Sets polariser to given value. Parameters: <PHASE> := phase of polariser; <AMP> := amplitude ratio of polariser.

TIME
Replies with current time of day (UT).

TRACE-ON
Traces execution of commands stored in a file when the execution of these commands has been started by giving the "RUN-PROGRAM" command.

TRACE-OFF
Stops the tracing started by the command "TRACE-ON".

TEST-COMMUNICATIONS
Tests communications between sites, the system replies (after a few seconds) with a message reporting the status of the communications system.

TRACE-STAR <NAME> <RA> <DEC>

Locks the antenna onto the given star. Parameters: <NAME> := name of the star ; <RA> := right ascension of the star (degrees) ; <DEC> := declination of the star (degrees).

UNLOAD-TAPE

If data taking has been stopped with the command "STOP-RECORDING-DATA" then unloads the tape otherwise gives an error.

WRITE-FILE <FILE NAME>

Writes a symbolic file to tape. This command must be issued after the "START-EXPERIMENT" command has been issued and is illegal during the time when data recording is running (i.e. in the interval between the commands "START-RECORDING-DATA" and "STOP-RECORDING-DATA"). Parameters: <FILE NAME> := name of file to be written to tape.

6. The TARLAN-BASIC programmers manual

6.1 Introduction

TARLAN-BASIC is a simple language for the description of Radar Controller pulse patterns. The TARLAN-BASIC compiler takes a TARLAN-BASIC program contained in a file and from this generates a series of Radar Controller instructions. Before describing the facilities implemented in the language a description of the Radar Controller and its interfacing to the EISCAT transmit and receive systems will be described.

6.2 The Radar Controller

The Radar Controller (RC) can from a functional point of view be considered a device that issues commands to different devices at a series of precisely defined times. In our case these instructions are issued with micro-second precision (it is this that makes the radar controller an expensive purpose built piece of equipment).

These commands are contained in the instruction memory of the RC. Each RC instruction can be considered as consisting of two 16 bit words containing respectivly a dwell time and an instruction, as in fig 6.1

```
< DWELL ( 1)>  < INSTRUCTION ( 1)>
< DWELL ( 2)>  < INSTRUCTION ( 2)>
.   .   .   .   .
.   .   .   .   .
< DWELL (N)>   < INSTRUCTION ( N)>
```

FIG 6.1 LAYOUT OF THE RADAR CONTROLLER MEMORY

The dwell time (units microseconds) is the time for which the specified instruction is to be executed.

The bits of both the dwell time and instruction word will be numbered from 0 - 15, 0 being the least significant bit. Bit 15 of both words is used as a parity check bit (odd parity is used, i.e. the total number of one bits in the word must be odd).

The units of the dwell time table are micro seconds counting from zero. That is, the number zero in the dwell time table instructs the RC to execute the current instruction in the corresponding element of the instruction table for one microsecond. 14 Bits are used for the dwell time allowing any dwell time in the range 1 - 32768 micro seconds to be specified. For longer dwell times the appropriate instruction must be replicated (this is performed automatically by the TARLAN-BASIC compiler).

Bit 14 of the instruction word is used to specify which of the two RC output drivers the specifed instruction is to be sent to. The RC has two output drivers, one is connected to the transmit system, the other to the receive system. The instruction is routed as follows:

Bit 14	= 1	Route instruction to transmit drivers
	= 0	Route instruction to receiver drivers

These are two physically separate drivers so we must always ensure that the correct system is being addressed before performing any action. Bit 10 of the receive word is physically connected to the start compute pulse that the RC sends to the analogue -> digital convertors. The remaining 13 bits of the instruction word can be used for any purpose. Conventionally we shall assign their meaning as in table 6.1

BIT 15	PARITY CHECK (ODD)	
14	TRANSMIT/RECEIVE SWITCH	'0' = RECEIVER '1' = TRANSMITTER
TRANSMITTER		
13	SYSTEM PULSE	'0' = OFF '1' = ON
12	HIGH VOLTAGE PULSE	'0' = OFF '1' = ON
11	R/F FREQUENCY INJECTION	'0' = RF OFF '1' = RF ON
10 - 5	NOT USED	
4	PHASE BIT	'0' = PHASE ZERO '1' = PHASE 180
3 - 0	LOGICAL FREQUENCY CHANNEL	1,2,..., 11
RECEIVERS		
13 -12	NOT USED	
11	RUN/BYPASS SWITCH TO MATCHED FILTERS	'0' = BYPASS MATCHED FILTERS '1' = RUN MATCHED FILTERS
10	START COMPUTE PULSE	
9 - 8	NOISE INJECTION BITS(9,8)	= (1,1) FOR 300 K NOISE = (1,0) FOR 100 K NOISE = (0,1) FOR 30 K NOISE = (0,0) FOR NO NOISE
7 - 0	LOGICAL SAMPLING CHANNEL	'0' = STOP SAMPLING '1' = START SAMPLING

TABLE 6.1 CONTROL SIGNALS FROM THE RADAR CONTROLLER

Before loading the RC the following actions take place:

1) The frequency channels are mapped (see section 6.0)
2) The sampling channels are mapped (see section 6.0)
3) Parity is set in the instruction and dwell time tables

6.3 General Format of TARLAN-BASIC Instructions

TARLAN-BASIC instructions have one of the following basic forms:

1/ <SITE>
2/ AT <TIME> <INSTR 1> <INSTR 2>
3/ SETTCR <TIME>
4/ END

Comments may be freely included on any line by use of the percent character "%". The start of the comment is signalled by the "%" character, the comment is terminated by end of line.

The <SITE> code must be one of 'KIRUNA' , 'TROMSO' , 'SODANK' or 'REMOTE'. This code is used to specify for which site the intended RC matrix is to be generated. When using the TARLAN-BASIC compiler the user must specify in the TARLAN-BASIC program which site is being considered. For example a file containing code for both Tromso and the remote sites should have the following format:

```
TROMSO
      ....
      CODE FOR TROMSO
      ....
REMOTE
      ....
      CODE FOR REMOTE SITES
      ....
END
```

Here 'END' specifies the end of all code.

The instruction codes <INSTR1> <INSTR2> etc. cause bits to be set or cleared in the RC command matrix. The time specified in the <TIME> field specifies the time at which the action is to be taken. This time can be any double integer quantity.

For example the instruction:

AT 12367 HVON	Sets the high voltage pulse on at time 12367 microseconds after the start of the current radar controller scan cycle.

All times must be specified in strictly increasing order. For example, it is illegal to say:

```
AT 12000   HVON      % SWITCH HIGH VOLTAGE ON
AT  2000   HVOFF     % SWITCH HIGH VOLTAGE OFF
```

Because the time reference is decreasing.

The command SETTCR <TIME> can be used to redefine the origin of all future time scale references. All future time references will be taken with TCR as origin. Originally TCR is set to zero. For example the code:

```
SETTCR  200
AT      300  HVON
```

Will switch the high voltage to the klystron on at time 500 relative to the start of the current Radar Controller cycle.

All SETTCR commands expect an absolute time reference. i.e. the sequence of commands:

```
SETTCR  100
AT      150  HVON
SETTCR  345
AT       10  HVOFF
```

Sets the high voltage off at absolute time 355 microseconds after the start of the current cycle.

6.4 Individual Instructions to Set/Clear bits in the radar controller

6.4.1 Transmitter Instructions

The following instructions are used to program the transmitter :

TRANS/SYSON/SYSOFF/HVON/HVOFF/F1/F2/F3/F4/F5/F6/F7/F8/F9/F10/F11/FOFF/PHA0/PHA180

They have the following meaning:

TRANS	sets the transmit receive bit to transmit
SYSON	sets the system pulse
HVON	turns the high voltage on
PHA0 - PHA180	selects a phase
F1 - F11	selects a logical frequency channel
FOFF	turns frequency off
HVOFF	turns the high voltage off
SYSOFF	clears the system pulse

These operations have to be done in the correct order. For example we cannot select a frequency if the high voltage is switched off. The correct sequence of operations to transmit a pulse is:

1) Switch to transmit (this sets the frequency and phase to 0 and all other bits off)
2) Switch system pulse on
3) Switch high voltage on
4) Switch phases or frequencies on
5) Switch phases or frequencies off
6) Switch high voltage off
7) Switch system pulse off

Each of these operations takes some time in the physical transmitter. We have to wait as follows:

20 Microseconds after switching the system pulse on before the high voltage can be switched on .
3 Microseconds after the high voltage has been switch on before any frequencies can be transmitted.

These times are as yet uncertain and will have to measured when the transmitter is installed.

The TARLAN-BASIC compiler will check the above sequencing of commands and a fatal error will be generated if the sequencing is broken. The times between different instructions are not checked. Errors are also generated when the user makes illogical requests, for example turning the high voltage on when it is already on.

6.4.2 Receive System Instructions

The following instructions are used to control the receive system

RECEV/CH1/CH2/CH3/CH4/CH5/CH6/CH7/CH8/CH1OFF/CH2OFF/CH3OFF/
CH4OFF/CH5OFF/CH6OFF/CH7OFF/CH8OFF/ALLON/ALLOFF/CAL0/CAL30/
CAL100/CAL300/STC/STCOFF/REP/RUN/BYPASS/B0/B1/B2/B3/B4/B5/B6/B7/B8/
B9/B10/B11/B12/B13/B0OFF/B1OFF/B2OFF/B3OFF/B4OFF/B5OFF/B6OFF/
B7OFF/B8OFF/B9OFF/B10OFF/B11OFF/B12OFF/B13OFF

They have the following meaning:

RECEV	sets the transmit receive bit to receive. All channels are set to stop sampling, the calibration noise is set to 0 K, the RUN/BYPASS switch to BYPASS
CH1-CH8	starts sampling on the selected logical channel (1-8)
ALLON	starts sampling on all channels
ALLOFF	stops sampling on all channels
CH1OFF - CH8OFF	stops sampling on the selected logical channel (1-8)
CAL0 - CAL300	selects a calibration noise (0,30,100,300 k)
STC	sends a start compute pulse to the correlator and analogue to digital convertors (ADC's).
STCOFF	turns off the STC pulse. Note: STC must be issued while at least one channel of the ADC's is sampling. When sampling on all channels is finished a start compute is sent from the ADC's to the correlator. This signal is inhibited if too many overflows are detected in the ADC's. STCOFF should be issued 1 microsecond after STC.
REP	repeats the whole cycle
RUN	sets the RUN/BYPASS switch in the ADC's to RUN.
BYPASS	sets the RUN/BYPASS switch in the ADC's to BYPASS.
B0 -B13	sets the specified bit on
B0OFF - B13OFF	sets the specified bit off

For the receive system the checking is less rigid, the exact sequencing of operations is less important. The only checks are that receive is selected before issuing any commands and that the user has not made any silly errors. For example, switching a sampling channel on when it is already on.

6.5 Running the TARLAN-BASIC Compiler

The TARLAN-BASIC compiler is installed as a :PROG file under the account (PREPASS). To start the compiler type:

(PREPASS)TARLAN

The compiler asks for the following:

1) Name of file containing the TARLAN program (extension :TLAN)
2) Name of file for output (default terminal)
3) Whether printout of the requested TARLAN program and generated code is required (Y gives printout to the file specified as the reply to question 2).
4) Whether generated program is to be dumped to a :TCOD file (this is the object form of the :TLAN code). Dumping takes place to a file with the same name as the file specified as the reply to question 1) only the extension :TCOD is assumed. If any compilation errors are detected then the file is not created.

6.6 Interface to the EROS system

The TARLAN-BASIC compiler is used off-line to create a RC program. The output of the compiler is a file of RC instructions. These instructions are stored in a form of code that is to a certain extent 'relocatable'. The frquency and sampling channels that the user specifies in the TARLAN-BASIC code do not necessarily correspond to the values that are loaded into the RC.

When the experiment is performed these channel numbers (we shall call them 'logical' channel numbers) must be converted to real frequency and reception channels (we call these 'physical' channels).

Immediately prior to loading the Radar Controller a mapping is made where the user specifies which logical channels are to be associated with which phsical channels. For example, logical frequency channel 1 in a TARLAN program might be connected to physical frequency channel 6, 2 to 4 etc. By default we shall map 1 to 1, 2 to 2 etc.

The reason for having such a mapping process is to enable the EISCAT staff to quickly reconfigure an experiment in case of equipment failure. For example, if frequency reception channel 4 fails then it can quickly be changed to another channel without changing the TARLAN and EROS programs controlling the experiment. All that has to be changed are the mapping tables.

The reception channel mapping is controlled by a table of the following form:

```
COMMON/MAP/MAPCHAN(8)
```

Where MAPCHAN(I) is the physical channel that will be used in the experiment corresponding to the users logical channel I.

User EROS control the user has options to:

1) Load the RC with a specified program
2) Instruct the RC to start execution of a program at a specified time and with a specified integration time
3) Stop execution of a RC program
4) Change the reception and frequency channel mapping tables

6.7 Programming of the buffer memory and analogue to digital convertors

The following program:

```
AT 10  CH1
AT 105 CH1OFF
```

Causes sampling on channel 1 to take place between times 10 and 105 microseconds relative to the start of the current radar controller scan cycle. As yet we have not specified what the analogue to digital conversion rate is to be on channel 1. This is done by a top level EROS command of the form:

SET-ADC-RATE <CHANNEL> <ADC RATE>

Which sets the ADC sampling rate as specified (see section 4.3.7 for details).

Suppose we set the conversion rate on channel 1 to correspond to taking one sample every ten microseconds. The first sample will be taken at time 10, the second at time 20 etc. and finally, the 10'th sample will be taken at time 100 (units of time are microseconds since start of rurrent radar controller cycle). Sampling is turned off at time 105 (this is exactly half way between two successive sample requests, this is chosen to minimise the chance of taking an incorrect number of samples).

The user must now specify where these 10 samples are to be stored within the correlator buffer memory. This is determined by commands of the form.

SET-BUFFER-MEMORY <CHANNEL> <LOCATION>

Which is used to set the correlator buffer memory start addresses. For example, the command:

SET-BUFFER-MEMORY 1,222

Would cause the first ten samples in any scan cycle that are taken on channel 1 to be stored starting from location 222 in the correlator result memory (see also secion 4.3.6).

Appendix 1.

```
:%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
:%%% COMMON PROGRAM 01 %%%%% 30-07-1980 %%%%%
:%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
:%%%%%%%%%% JOE ARMSTRONG %%%%%%%%%%%%%%%%%%
:%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                        % THIS PROGRAM MUST BE CONTAINED
                                        % IN A FILE CP1-TROMSO
                                        % THE PROGRAM IS STARTED BY THE COMMAND
                                        % RUN-PROGRAM CP1-TROMSO,<TIME>

:%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
:%%% TAPE INITIALISATION %%%%%
:%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

TART-EXPERIMENT HAGFORS,CP1,1
RITE-FILE FORMATS:DATA
ET-DATA-LENGTHS 1030,0                  % LENGTH OF CORRELATOR OUTPUT/SPECIAL
                                        % DATA OUTPUT


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% ANTENNA INITIALISATION %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

OINT-REFERENCE-HEIGHT 183.2,77.6,103. % FIRST POINT

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% RECEIVER INITIALISATION %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

ET-SIGNAL-PATH 0
ET-RECEIVERS
ET-FILTER 1,2                           % CHANNEL 1 25 KHZ
ET-FILTER 2,3                           % CHANNEL 2 50 KHZ
ET-LO1 0                                % LO1 = 1053.5
ET-LO2 1,96                             % LO2 (CHANNEL 1) 152.5 MHZ
ET-LO2 2,95                             % LO2 (CHANNEL 2) 152.0 MHZ
UN-RECEIVERS

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% RADAR CONTROLLER INITIALISATION %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

OAD-RC CP1,30,1,10                      % PROGRAM IN BUFFER 1 OF FILE
                                        % CP1:TCOD START AT 30 SECOND RELATIVE
                                        % TO VCR INTEGRATION TIME = 10

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%% CORRELATOR/BUFFER MEMORY/ADC INITIALISATION %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
                                        % LOAD CORRELATOR
OAD-CORRELATOR-SPECIAL-PROGRAM CP1      % CORRELTOR PROGRAM FOR CP1
ET-CORRELATOR-APB 15,12                 % # LAGS IN SINGLE PULSE ACF -1
ET-CORRELATOR-APB 14,32                 % # SIGNAL GATES -1
ET-CORRELATOR-APB 13,-4                 % # OVERLAP - # LAGS/ACF +1
ET-CORRELATOR-APB 12,1                  % CONSTANT
```

```
SET-CORRELATOR-APB 10,9          % # NOISE GATES -1
SET-CORRELATOR-APB  9,9          % # CALIBRATION GATES -1
SET-CORRELATOR-APB  8,4          % # SUB PULSE IN MULTI-PULSE -1
SET-CORRELATOR-APB  7,23         % # SIGNAL GATES -1
SET-CORRELATOR-APB  6,1          % CONSTANT
SET-CORRELATOR-APB  5,9          % # NOISE GATES -1
SET-CORRELATOR-APB  4,9          % # CALIBRATION GATES -1
SET-CORRELATOR-APB  3,3          % SAMPLE DISTANCE BETWEEN 4TH LAST & 1ST
                                 % PULSE
SET-CORRELATOR-APB  2,4          % DITTO 3RD
SET-CORRELATOR-APB  1,9          % DITTO 2ND
SET-CORRELATOR-APB  0,11         % DITTO 1ST
SET-CORRELATOR-APM 15,13         % LAGS IN SINGLE PULSE
SET-CORRELATOR-APM 14,1          % CONSTANT
SET-CORRELATOR-APM 13,1          % CONSTANT
SET-CORRELATOR-DATAIO 1030       % # WORDS TO BE OUTPUT
RUN-CORRELATOR                   % START EVERYTHING IN CORRELATOR

SET-BUFFER-MEMORY 1,0            % START ADDRESS OF CHANNELS
SET-BUFFER-MEMORY 2,689

SET-ADC-RATE 1,300               % 30 MICROSECONDS
SET-ADC-RATE 2,800               %  8 MICROSECONDS

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%% START DATA TAKING %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

STOP-RC
START-DUMPING-COMMUNICATIONS
START-DUMPING-DATA
START-RECORDING-DATA
START-RC 400,1,10
SYNC 400                         % HERE WE ALLOW 400 SECONDS
                                 % FOR THE ANTENNAE TO GET TO
                                 % POSITION BEFORE STARTING THE
                                 % EXPERIMENT. THE START-RC
                                 % COMMAND STARTS THE RADAR
                                 % CONTROLLER AT 400 SECONDS
                                 % RELATIVE TO THE EXPERIMENT
                                 % SCHEDULING TIME (THE SAME TIME
                                 % AS WHEN THE SYNC CONDITION IS
                                 % SATISFIED).

%%%%%%%%%%%%%%%%%%%%%%
%%%%% SCAN CYCLE %%%%%
%%%%%%%%%%%%%%%%%%%%%%
REMOTE R                         % SELECT REMOTE SITES
    DO -1                        % -1 MEANS FOREVER
                                 % ANTENNAE ARE AT 103 KM
                                 % MEASURE FOR 80 SECONDS
        SYNC 80
        STOP-RC
        START-RC  3,1,10         % RESTART RC IN  3 SECONDS
        MOVE-HT +7               % ALLOW  3 SECONDS FOR ANTENNA
                                 % MOVEMENT
        SYNC 83                  % MEASURE FOR 80 SECONDS
                                 % (SYNC 83 BECAUSE  3 SEC. ALLOWED
                                 %  FOR ANTENNAE MOVEMENT)
```

```
      STOP-RC
      MOVE-HT +190.                         % ANTENNAE UP TO 300 KM
      START-RC 25,1,10                      % 25 SECONDS FOR NEXT ANTENNAE
                                            % MOVEMENT
      SYNC 105                              % 80 SECONDS INTEGRATION + 25 TO MOVE
      STOP-RC
      MOVE-HT -197.                         % BACK DOWN TO 103 KM
      START-RC 26,1,10                      % TAKES 26 SECONDS
      SYNC 26                               % TO CLOSE LOOP READY FOR NEXT
                                            % TIME ROUND
   ENDDO                                    % END LOOP
LOCAL                                       % BACK IN LOCAL MODE
RETURN                                      % TO COMMAND PROCESSOR
ENDDO

%%%%%%%%%%%%%%%
%%%%% END %%%%%
%%%%%%%%%%%%%%%
```

Appendix 2.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%% COMMON PROGRAM ONE %%%%%%%  JOE ARMSTRONG %%%%% 25-07-1980 %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%
%% CODE FOR TROMSO %%
%%%%%%%%%%%%%%%%%%%%%
TROMSO
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%% TROMSO TRANSMITTER INSTRUCTIONS %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
AT     1 TRANS                 % SELECT TRANSMITTER (TX)
AT     2 SYSON                 % SYSTEM PULSE TO TX
AT     5 HVON                  % HIGH VOLTAGE ON
AT    35 F3                    % LONG PULSE (600 US.) FOR REMOTE SITES
                               % 'BEAM RISE TIME' IS SET TO 30 US.
SETTCR   635                   % DEFINE NEW ZERO FOR TIME SCALE
                               % (TOO MAKE DEFINITION OF MULTIPULSE EASIER!)
AT     0 F1                    % START OF MULTIPULSE (F1 CHANNEL)
AT    30 FOFF                  % (BAUD OF MULTI PULSE = 30 US.)
AT    90 F1                    % MULTI PULSE HAS 5 SUB PULSES
                               % AT POSITIONS (1,4,5,10,11)
                               % LAGS MEASURED ARE (1,2,3,4,5,6,7,8,9,11)
                               % LAG 10 MISSING
AT   150 F2                    % 'LONG' MONOSTATIC PULSE (F2 CHANNEL)
                               % = 120 US.
AT   270 F1
AT   300 FOFF
AT   330 F1
AT   360 FOFF HVOFF
AT   362 SYSOFF
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%   TROMSO RECEPTION   %%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
AT    400 RECEV
                                  % IN WHAT FOLLOWS THE FOLLOWING SAMPLING RATES
                                  % ARE ASSUMED:
                                  %     CHANNEL 1 = 30 US.
                                  %     CHANNEL 2 =  8 US.
                                  % THE NUMBER OF POINTS IN A GIVEN SAMPLING
                                  % WINDOW CAN BE CALCULATED AS FOLLOWS:
                                  %     TOFF = TON + (N-1)*TSAMP + TSAMP/2
                                  % WITH:
                                  %     TOFF = END   OF SAMPLING WINDOW
                                  %     TON  = START OF SAMPLING WINDOW
                                  %     N    = # POINTS IN SAMPLING WINDOW
                                  %     TSAMP= SAMPLING RATE (US.)
                                  % NOTE: THE FACTOR TSAMP/2 ARISES TO ENSURE
                                  %       THAT TOFF OCCURS EXACTLY HALF WAY
                                  %       BETWEEN TWO SAMLE REQUESTS. THIS IS
                                  %       TO ENSURE AN EXACT NUMBER OF SAMPLES
                                  %       BEING TRANSFERRED TO THE BUFFER MEMORY
                                  %
SETTCR    0                       % BACK TO ZERO TIME SCALE
AT   1295 CH1                     % START SAMPLING ON CHANNEL 1 (MULTIPULSE)
AT   1635 CH2                     % START SAMPLING ON CHANNEL 2 (LONG PULSE)
AT   2330 CH1OFF                  % END SAMPLING MULTIPULSE
                                  % # POINTS IN BUFFER MEMORY = 35
                                  % # ACFS = 24
                                  % HEIGHT RANGE WITH MULTIPULSE = 99 - 202.5 KM
AT   3527 CH2OFF                  % END SAMPLING SINGLE PULSE
                                  % # POINTS IN BUFFER MEMORY = 237
                                  % # ACFS = 29
                                  % HEIGHT RANGE 127.5 - 396.3 KM
AT   4094 CH2                     % SINGLE POINT AT 500 KM
AT   4218 CH2OFF                  % # POINTS IN BUFFER MEMORY = 16
AT   5761 CH2                     % SINGLE POINT AT 750 KM
AT   5885 CH2OFF                  % # POINTS IN BUFFER MEMORY = 16
AT   7451 CH2                     % START OF NOISE CALIBRATION (CHANNEL 2)
                                  % 10 GATES STARTING AT 1000KM
                                  % (COULD ALSO ANALYSE AS SIGNAL!)
AT   7500 CH1                     % START OF NOISE CALIBRATION (CHANNEL1)
AT   8100 CH1OFF                  % END OF NOISE CALIBRATION (CHANNEL 1)
                                  % # POINTS IN BUFFER MEMORY = 21
                                  % # ACFS = 10
AT   8127 CH2OFF                  % END OF NOISE CALIBRATION (CHANNEL2)
                                  % # POINTS IN BUFFER MEMORY = 85
                                  % # ACF LAGS = 10
AT   8150 CAL100                  % 100 K NOISE INJECTION
AT   8200 CH1 CH2                 % START SAMPLING ON CHANNELS 1 AND 2
AT   8800 CH1OFF                  % END OF SAMPLING (CHANNEL 1)
                                  % # POINTS IN BUFFER = 21
                                  % # ACFS = 10
AT   8870 STC                     % START COMPUTE WILL BE ISSUED THE NEXT TIME
                                  % ALL CHANNELS HAVE STOPPED SAMPLING
AT   8876 CH2OFF                  % END OF SAMPLE (CHANNEL 2)
                                  % # POINTS IN BUFFER MEMORY = 85
                                  % # ACFS = 10
AT   8995 REP                     % REPETE CYCLE (CYCLE IS FOR 5 US LONGER
                                  % THAN THE TIME GIVEN IN THE 'REP' COMMAND)
                                  % I.E. TOTAL CYCLE TIME WILL BE 9000 US.
END .
```

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