SOFTWARE ON THE STATION COMPUTER AT A GMRT ANTENNA

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1. INTRODUCTION

What follows is a preliminary description of station computer software for GMRT antennas. This is more like a collection of ideas on the organisa- tion of this software.

The Station Control Computer (SCC)is expected to be a single board system having 2 RS232 communication ports (for connection to the Central Control Computer [CCC] and an optional keyboard), 2parallel ports (for interfacing with the servo system and with the control/monitor system), a video output for a VDU, a real-time clock, about 64kB EPROM for program memory and about 512kB RAM for data memory. The data memory is preferably battery-backed since we expect to be able to accumulate monitored information for extended periods (typically 15 minutes but may be as long as a couple of hours in the worst case). The transmission of monitored data to the CCC will occur at irregular intervals, typically when the antenna has to point to a different source or some· settings for the observations are to change or when we have to turn on noise-generator calibration, etc. However, any emergency at the station is communicated within a few seconds.

2. SOFTWARE PHILOSOPHY: -

Station control software is organized around an interrupt-driven supervisor which co-ordinates communication with the CCC, the antenna servo- control, monitoring/controlling the RF/IF electronic subsystems, display of various parameters on the VDU and keyboard interaction for trouble-shooting purposes. Four interrupts are envisaged, namely:

(i) **Timer interrupt** - occurs once a second. This is used for scheduling various tasks.
(ii) **Communication port** -- The serial port connected with the

(iii) **Keyboard interrupt**. --- Every character typed by the user causes an interrupt.

(iv) **Servo system** -- Any alarm condition in the antenna servo system causes this interrupt.

3. TASKS AT THE SCC:

The various tasks to be performed by the SCC are:

1. Receive instructions from the CCC and act upon them. These will generally be in the form of ASCII characters, except while a code (image of a special purpose task, say for diagnostic purposes) is 2. Send current status to the CCC periodically and the accumulated status typically in l5-30 minutes. The current status is a coded, overall status indicator which indicates the quality of data from the astronomer's point

of view and the severity of malfunctioning of the worst subsystem from the point of view of engineers. This will be two characters (one for astronomer and one for engineer), which the CCC should be receiving every 5 sec if the link is working properly. 3. Provide control for the antenna servo system. We expect to communicate to the servo system, alt-az coordinates and their rate of change (in the form required by the servo group) at intervals of 5 sec; the antenna coordinates in the intervening time may be generated by the servo controller by assuming a linear change as per the rate specified. The other controls like stopping the antenna or those related to reading encoders or environment parameters like wind will be given as per the specifications of the servo-group. We would also like to communicate, say every 5 sec, the astronomical time to the servo controller so that the servo-controller can use its internal clock to update time, if needed, in the intervening period. On an interrupt from the servo system, we will read the status related to any fault or to find out if the previous command has been successful. For instance, this might indicate that the antenna is on target within pointing error and tracking has begun.

4. Set control bits in the electronic subsystem for selecting the configuration appropriate for the observation, e.g. feed, LO frequency NG cal, attenuators, SAW filters etc. 5. Monitor the health of the complete system and store the status in the RAM (double buffer). We expect to be able to monitor about 20-30 ADC channels (12 bit ADC) and digital information upto a total of 32 bits. It is possible that we will re-scale the ADC values to 8 bits as per scale factors recommended by the engineers and thus accumulate about 40 bytes of monitored information including time- stamp. This information is obtained at, say 5 second intervals, but assessed as per criteria to be specified by the engineers to form a 2-4 bit status word for each monitored point. By ORing all such status words we will form a global status for each 5 sec. This will be converted to 2 character information (one for engineers and one for astronomers) indicating the health of the system and the degree of validity of astronomical data. We expect to communicate this status word (2 characters) each 5 sec to the CCC. However, at intervals of 1 minute, we will save the entire 40 bytes of monitored information to be eventually communicated to the CCC. The average data rate implied in this routine communication of monitored information is about· 17.5 characters per second from each of the 34 antennas, or about 600 bytes total from all the 34 antennas to the CCC.

6. Take specific action in case of failure of any component in the system. This will be in accordance with any such prescription from the designers of subsystems being monitored by us. In addition, we also plan to provide power-failure recovery support so that the system monitor status accumulated in the data RAM is not lost.

4. COMMUNICATION WITH CCC

Communication between the SCC and CCC is via RS232C link. At the CCC, we plan to group RS232C signals from specific antennas (e.g. arm of Y, grating) into terminal concentrators so that the CCC sees the antennas as belonging to one of several terminal concentrators, each appearing as a terminal with an overall speed upto l9.2kbaud. (The number of antennas in each terminal concentrators will be within 7 or 3 depending on whether we choose 2400 or 4800 baud rate for communication between a given SCC and CCC.)

Commands and data are exchanged in fixed-length packets (40 or 80 bytes), which contain:

1 byte destination/source address

2 byte packet sequence no. (relevant if the logical packet overflows the adapted packet size) 1 byte length of logical packet contained in this packet

n bytes actual packet related to command/status

…..repetion of the above for the next command/status

…if the packet is very small

2 byte CRC.

As indicated above, multiple commands and data are packed into a packet if space permits. The CRC at the end enables the receiver to request for a specific packet in case, of error. There will be a check on the maximum number of consecutive packets where error was detected (e.g. 3-5), which is taken to indicate a temporary loss of Communication. The exact action in such cases is still under consideration, but we envisage a deliberate restriction of communication to bare minimum allowing for only critical packets to be sent. As part of protocol internal to our software, we will be sending a handshake code each time nothing is sent from the station to the master during the last 5 seconds, Similarly, if CCC has nothing to be sent to a station for 5 seconds, it will send a handshake code. Whenever a packet is received, the SCC or CCC will send an acknowledgement to the sender indicating the packet number.
Some of the commands envisaged are:
(i) Move antenna to given alt-az coordinates

(ii) Stop antenna

(iii) Accept coordinates (date) and rate of change (formoving sources) for the source to be observed next

(iv) Accept parameters relevant for the next observation, e.g. source name, latest start time, duration of observation, settings of feed etc., pertaining to that observation. The idea is that the observing program on the SCC will have separate buffers for the current source and the next observation so that the information pertaining to next observation can be sent while the observation is going on. We expect to use the start time and duration only there is failure in the communication between SCC and CCC; otherwise, normally switching to next source will be effected as soon as the appropriate command is received from CCC for changeover. The source name coordinates actual start time and actual duration of observation will be part of the monitored information base as well as significant tracking errors. These will, however, be added to the packet sent to CCC by the observing task rather than routinely by the supervisor.

(v) Read and immediately return the monitor status at a given address.

(vi) Add or delete the monitor address/es to the list included for the routine monitoring

(vii) Selecting operating frequency

(viii) Set the observation parameters for the next source

(ix) Acknowledge

(x) Accept downloaded code to be loaded into specified address and to be named as indicated in the command line

The observing program on the CCC will meet the requirements of observers by sending such commands to the SCC. All these commands (except, of course, downloaded code for special diagnostics purposes) are sent as ASCII as already mentioned. The SCC cannot distinguish between such commands sent by the CCC or through some terminal connected on the corresponding RS232 port.

5. MODULE LAYOUT OF SCC PRGRAMS:-

The essential layout of the program residing in SOC is given in Fig 1. Here, we give a brief functional description of each module. The general philosophy is to have a supervisor module which includes command parsing and interrupt servicing facility, and scheduling of specific tasks which will be like subroutines starting at addresses contained in a table of names and addresses maintained by the supervisor. The main purpose of the following description is to give a general feeling of the software planned for the 5CC. The details of all these modules are not yet fully worked out, as are the other modules not discussed here.

(a)INIT: This module is entered at power ON or when RESET is pressed on the SCC. This basically sets up communication port speed, does a power fail check to ensure that any valid data still in RAM are not lost. It then sets up various pointers, initializes the interrupts and then just waits for some interrupt to occur.

(b) SERVO ERROR HANDLER: In case of serious problems in antenna or servo electronics this interrupt occurs. The general philosophy in the design is such that any urgent action following an emergency is initiated independently by the servo or other electronics module. The idea of interrupt is to let the SCC know the situation immediately so that appropriate flagging of data is possible and to communicate soon (within seconds if link is healthy) to the CCC of the occurrence of a serious fault, if necessary. However, such emergency messages are expected to be cryptic and the details of faults will have to be obtained from the monitored data, which may be sent to CCC after a lapse of some time. (We are considering a special command at the CCC to obtain the monitored database immediately from a selected antenna in order to satisfy the curiosity of specially inquisitive personnel who might be around when a fault was communicated)

(c) KEYBOARD HANDLER: The keyboard is used to enter commands during field trouble-shooting and as such is normally disabled in a routine observing program -- it will be enabled as soon as the observing program is complete or terminated. All commands are terminated by a carriage return. The keyboard is read on a per-character interrupt basis and the data assembled in a buffer. The interpretation is only performed when a carriage return is typed. Since this facility is exclusively for diagnostic purposes, the command list depends on the needs of designers of individual subsystems at the station. It should in principle be possible to execute any command available from the CCC also through the keyboard. It is not necessary to permanently retain keyboards at all the 34 stations because of its limited use for field engineers. They can easily be carried by the field engineers and plugged in whenever needed.

(d) INPUT HANDLER: This is entered whenever a character is received from the CCC. The character is read into a buffer and after a packet is received in full (80 or 40 bytes depending on our final choice), a

CRC check is performed. It is then entered in the command queue if the packet was error-free; otherwise, it is flagged for repeat request if necessary.

(e) OUTPUT HANDLER: This just dumps the next character from the buffer packet to the communication port. After the complete packet has been transmitted it sets a flag to indicate that the packet has been sent.

(f) SERVO MODULE: This checks the status of the servo system and, if a positioning command is in progress, it loads the new coordinates for the antenna. It also verifies that the antenna is moving in the right direction by reading the encoder readings. If the observation has begun, it includes the antenna position error into the monitored database. The indication about the start of observation comes from the CCC if the link is judged healthy, otherwise the start time in the SCC buffer itself is taken as the start time of data acquisition. If there is any fault or alarm condition sensed by the servo controller, we expect that there will be an interrupt from the servo controller and the relevant status is read. It is assumed that the emergency action necessitated by the alarm has been taken by the servo controller independently and the SOC only needs to record the event to be communicated eventually to the CCC.

Monitoring of electronic subsystem is done here. There is a control/monitor subsystem which can be instructed to provide the status of a particular signal (like phase of LO, temperature, status of power supplies etc.) At the start of the observation, the supervisor creates a table of addresses which are to be monitored once every 5 sec. This routine runs through these addresses sequentially and we expect all the critical addresses to be monitored within S sec. In other words, the monitored addresses will have two levels of priority. The critical addresses are necessarily monitored every 5 sec. As many of the other addresses are monitored in the S sec slot as possible such that at the end of every minute, all the required addresses are monitored at least once. As already stated, W the 5 sec data will be used to create an overall status flag to indicate to the astronomer or diagnostic engineer the degree of integrity of the system. At one-minute interval, the entire monitored data base (one for every address) is saved in the buffer, to be eventually communicated to the CCC. We will employ double buffer scheme so that while one buffer is being communicated to the CCC, other buffer is used for saving the monitored information.

(h) COMMAND EXECUTION MODE: This looks at the command queue and if a command is waiting to be executed, it parses the command and calls the appropriate subroutine to execute the same.

(i) DISPLAY ROUTINE: This routine updates the status display on the VDU screen at regular intervals (1 sec?, S sec2').

(j) HOUSE KEEPING ROUTINE: This routine attempts to clear up everything that is hanging loose. This has subroutines to check if link to CCC is healthy (by verifying ·that at least one packet has been received in the last l0-l5 sec) and take appropriate action for erroneous packets; For instance, a repeat request is sent to CCC if CRC error was detected as' indicated by the flag set by the Input Handler. Or, a packet not acknowledged by CCC may be sent again, and so on. When the monitor buffer is full or a time-out or change in antenna set up occurs, this routine formats the buffer into packets of fixed length, encodes error and marks it for transmission to the CCC.

Module Layout of SCC Software

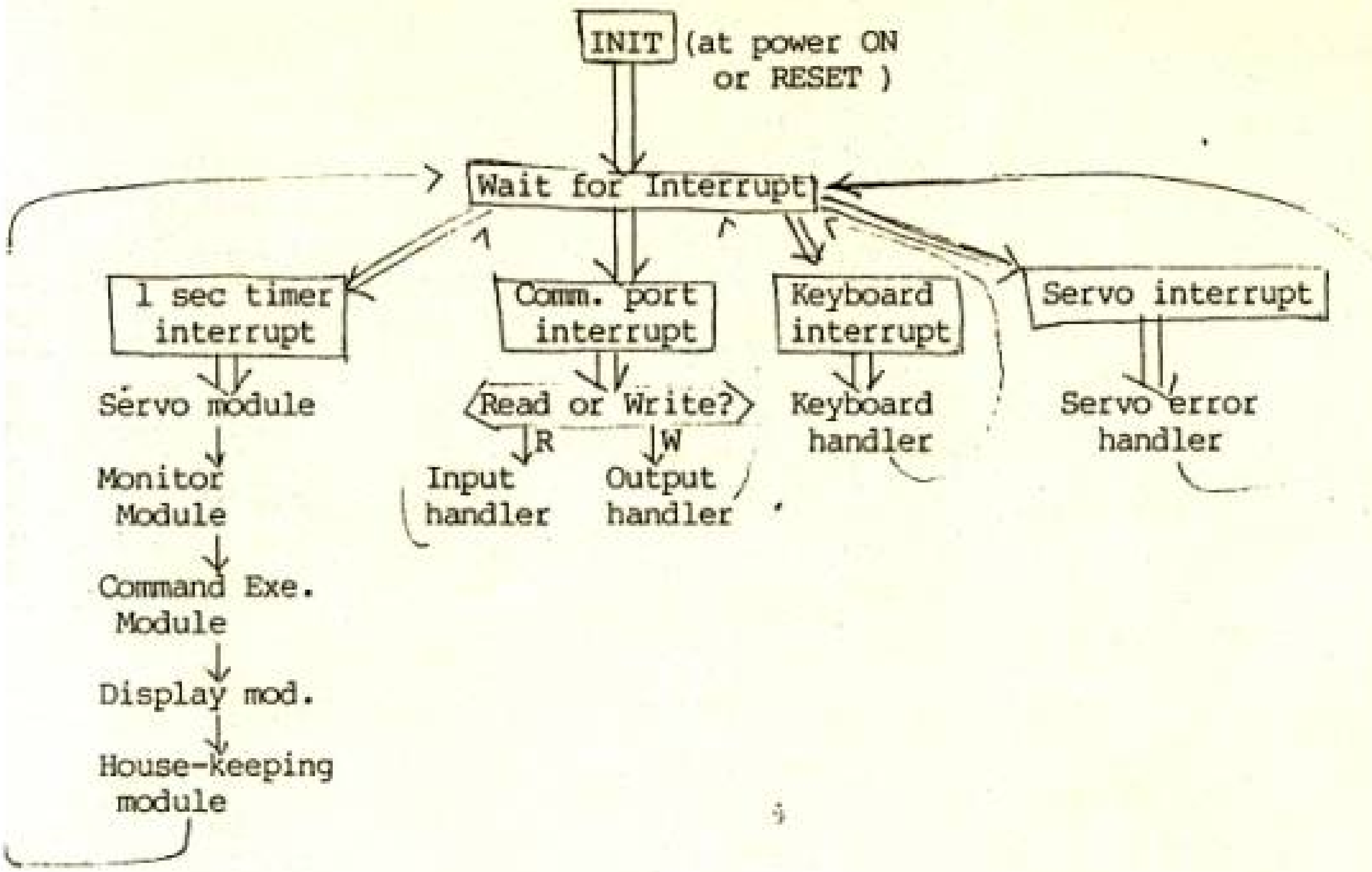

Fig 1. Module Layout of SCC Software

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