

Scintillation Monitor Operations

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For SCINTMON running in DOS using ISA GSPBuilder-2.1 boards

General

The Global Positioning System (GPS) ionospheric scintillation monitor (“ScintMon”) developed by Cornell University’s Space Plasma Physics group consists of a modified GEC Plessey GPS Builder-2™ development kit. As such, most of its operation is similar to the operation of the development software that comes with the kit. Significant modifications include: (1) elimination of all the portions of code pertaining to differential corrections, (2) addition of Fast, Scintillation Log (FSL) file capability, (3) an updated carrier-to-noise ratio estimator for the display, (4) addition of a delayed command execution function, and (5) user specification of RINEX2 and FSL header fields. To support these modifications, several new receiver commands have been added, old commands have been deleted and the displays have been updated. This manual, intended to supplement the GPS Builder-2™ Designer’s Guide, summarizes the changes and other important aspects of operation.

Setting up (Hardware)

In order to use the scintillation monitor, you must have a PC-compatible computer (preferably having a 100 MHz or faster Pentium® processor and at least a 1 GB hard drive) with the Plessey GPS card installed into an ISA slot. Jumper *JP4* on the card determines which PC interrupt (IRQ) the card uses for processing. This will typically be set to IRQ 11, with IRQ 10 as a backup in case there is a conflict with pre-existing hardware. A DIP switch on the card determines which DMA addresses the card will use in the processor’s address space for communication and control. The card’s starting DMA address is usually set to 300 (hexadecimal). Refer to section 1.3 in the GPS Builder-2™ Designer’s Guide for information on changing the IRQ and DMA settings if the default settings do not seem to work.

Note that almost all modern computers have enough extra hardware and software “features” to cause interrupt or memory conflicts with the GPS card and receiver software. Examples of common features which are known to cause conflicts include: DOS mouse drivers, sound cards, modem cards, certain SCSI card configurations, power management software and various Windows drivers. Effects of interrupt and memory conflicts range from missed accumulation data to receiver software lockup. Experience has shown that the best chance for successful setup and operation of the GPS card and software comes with the simplest systems.

In plain language, view all computer features which are designed for “easy setup” or to make the computer “user friendly” or into a “multimedia center” with suspicion. Setting up the GPS card will be far easier if you eliminate all unnecessary hardware and software from the computer used for controlling the receiver at the outset (including careful editing of the CONFIG.SYS and AUTOEXEC.BAT files to eliminate unnecessary drivers). For example, the current Cornell Portable Scintillation Monitor computers have only VGA graphics cards, a CD burner and GPS cards installed; —no sound cards, modems, etc. Furthermore, these computers use the older DOS/Windows 95 operating system.

Returning to the GPS card itself, note that the daughter board has some jumpers as well. These should normally be left alone. One of these jumpers, *JP2*, is important to check when troubleshooting, however. The Plessey GPS card requires a pre-amplified antenna to operate (the supplied M/A-COM “hockey puck” antennas provide 26 dB of gain). Jumper *JP2*, when installed, allows the 5 volt DC regulator on the GPS board to supply power to the antenna preamplifier via the antenna cabling. *Important note: The GPS Builder-2™ manual incorrectly refers to the antenna power supply jumper as JP3. The correct jumper is JP2. If in doubt, trace from the 7805 regulator IC (3 pin case, looks like a transistor) to the socket of the short run of coaxial cable to the antenna connector to find the correct jumper. Please refer to Figure 1. at the end of this document.*

Mount the antenna by means of the magnet attached to its underside. The antenna should be placed on a suitable piece of steel, roughly 50–100 cm on a side, which acts as a ground plane. For the October 1996 campaign, Cornell provided ground planes made of sheet steel. Set the ground plane level in a spot where it has an unobstructed view of the sky —ideally, from horizon to horizon at all azimuth angles. Potential obstructions includes trees, hills, buildings and metal structures (cars, fencing, vents, etc.). Remember that GPS signals have about a 19 cm wavelength and therefore can scatter effectively from small structures. When scattered GPS signals reach the antenna, their interference with the direct signal from the satellite is called *multipath*. Multipath causes variations in signal amplitude and alters the timing code that GPS uses for ranging.

The ideal spot to place the antenna would be on the ground in an open field, away from trees, hills, buildings, etc. Since such spots are not always available, or near a suitable place to operate the computer, the next best alternative is to place the antenna on a roof, above as many obstructions as possible. Set the antenna above any vents or structures and away from the edge of the roof. Also, stabilize the antenna so that it won't fall off or blow down in stiff wind, by tying down the ground plane if necessary. Wherever you place the antenna, make sure to note all potential obstructions in the site log (by azimuth and the estimated highest elevation where they can be seen from the antenna).

If you do choose a roof site, or other elevated site, for the GPS antenna, be aware that our experience has been that you *will* see multipath, regardless of how few obstacles are visible above zero elevation. We currently believe that the multipath seen on elevated antennas stems from the imperfect nature of the ground planes; that is, reflections from the ground “leak” into the antenna and interfere with the direct signal, even at negative elevation angles. Multipath produces variations in signal strength which may be difficult to distinguish from scintillations under some circumstances. Two characteristics of multipath allow it to be identified. First, multipath variations tend to repeat from one day to the next since the satellites follow nearly the same track across the sky on successive days. Second, multipath variations typically have longer time scales than scintillations. For example, equatorial scintillation periods are on the order of tens of seconds, while multipath variations occur on time scales of minutes. (Note, however, that there is some overlap between the fastest multipath and the slowest scintillations.)

Cornell has provided a 10 meter section of low-loss coaxial cable to be used with each antenna. The low-loss cable connects to the antenna and receiver at the ends by short pieces of smaller diameter cable, which is more flexible but also more lossy (in addition to the 10 meter cables, each receiver setup has a 10 meter piece of smaller diameter cable for a backup). When running the cable, be careful not to allow the cable to be kinked, snagged or pinched. When connecting the cables to the antenna or receiver, do not over-tighten or force the connectors. The SMA-type connectors used by the GPS card and the antenna may be damaged more easily than other, larger RF connectors.

Finally, before plugging the computer in, be sure that the computer is set to the correct local power supply voltage: 110 or 220 VAC. Power quality is also an issue, but is more likely to be out of the

experimenter's control. If an uninterrupted or filtered power source is available, that supply should be used. Any transient which causes the computer to reset will stop data logging. Consequently, make sure that the computer automatically starts the scintillation monitor program with data logging when it boots up (from the AUTOEXEC.BAT file, see below). That way, power problems will cause only temporary interruptions, rather than complete data loss for the rest of the night.

Setting up (Software)

The ScintMon software may be pre-installed on the computer in the directory C:\SCINTMON, or it may be provided on a floppy disk. If the software is not pre-installed, perform the following set of operations: (1) change to the root directory on the hard drive (cd c:\), (2) make a new directory called SCINTMON (md scintmon), (3) change to the SCINTMON directory (cd scintmon), (4) place the floppy disk in the A: drive (or whichever is the appropriate drive), and (5) copy the files from A: to the SCINTMON directory (copy a:.* c:).

The ScintMon package provides the following files:

File Name	Description
SCINTMON.EXE	Scintillation monitor program, Ver. C1.33 ()
GPSBLDR2.EXE	Original GEC Plessey receiver program
GPSBLDR2.CFG	Configuration file for SCINTMON/GPSBLDR2
CMD.INI	Initial command file for SCINTMON/GPSBLDR2
ALM.INI	Initial GPS satellite almanac for SCINTMON/GPSBLDR2
SCANFILE.EXE	Graphical FSL file scanning utility, Ver. 1.32 (970306)
HELVB.FON	Font file for SCANFILE
READFSL.EXE	FSL file reading utility, Ver. 1.50 (960816)
FEXTRACT.EXE	FSL signal strength extraction utility, Ver. 1.41 (971125)
SUM.EXE	Summary file (*.sum) creation program, Ver. 1.10 (980511)
STARTLOG	Sample command file for automatic start
STOPLOG	Sample command file for automatic stop
README.DOC	Release notes, including known bugs and workarounds

The initial command file and the configuration file (see **Appendix** for example files) must be modified prior to using the software (either SCINTMON or GPSBLDR2). The initial command file contains the starting guess for the receiver's position, the number of channels that the receiver will use to track GPS signals, the elevation mask angle, header information and settings for various other operating parameters. The configuration file contains three parameters which must be set properly in order for the receiver to function. These three parameters are the DMA address and IRQ number, which must be set to match the hardware settings (see previous section), and the offset between Universal Time (UT) and local time where the receiver is operated.

Use a text editor (e.g., EDIT or Write) to modify the command and configuration files for your station. *Important: The initial position (IP line in CMD.INI) must be set to within about a degree of the correct receiver location.* While GPS can be used to find a user's position from an unknown starting point, the GEC Plessey software, on which ScintMon is based, requires a good initial guess or it will not operate. Estimating the initial position from a map is usually accurate enough. Command syntax for IP is *IP latitude longitude*, where *latitude* and *longitude* are in position format. Position format is *Dddd*

mm.mm, where *D* is the direction character (N, S, E or W), *ddd* are integer degrees and *mm.mm* are minutes (including a decimal part, if necessary). Also, set the reference position (RP line, same format as IP) to the initial position guess.

The elevation mask should be set to 10 degrees (*EM 10.0* command) to prevent GPS satellites at low elevations from being tracked, thus avoiding *some* problems with multipath. The number of channels should be set to 12 (*CH 12* command) so that GPS satellites may be tracked on all the available channels of the GPS card. Leave the maximum GDOP (Geometric Dilution of Precision) set to 99.0 (*GM 99.0* command). The remaining lines in CMD.INI determine the single character station identifier and various blocks of header information for the output files.

The single character station identifier (*ST x* command, where *x* represents a number or a letter) determines the FSL and RINEX output filenames to be used. For current use, the following station identifiers are assigned:

Station	ID Character
Tucuman, Argentina	A
Natal, Brazil	B
San Jose dos Campos, Brazil	C
Ancon, Peru (station 1 – West)	P,Q
Maui, Hawaii, USA	U
Santa Maria, Brazil	S, T
Macaes, Brazil	M
Cuiaba, Brazil	J, K
Sao Luis, Brazil	H, I
Cachoeira Paulista, Brazil	F, G

Note: We will supply you with a station identifier in a supplemental letter that you should receive with this document.

Automatically generated filenames are in the following format: *yymmddIn.FSL* (for FSL files) or *yymmddIn.N* (for RINEX2 navigation files), where *yy* are the last two digits of the UT calendar year, *mm* and *dd* are the UT month and day, *I* is the station identifier character and *n* is the file number (0–9), in case several files are taken during a single day. For example, the first FSL file logged on 6 Oct 2001 at Tucuman, Argentina would be 011006A0.FSL.

All of the commands in CMD.INI which begin with the letter H are used to set header information in the FSL and RINEX files. The header commands must be followed by a space and then the string to which the appropriate header block is to be set. Header setting commands are:

Command	Description	Characters
HA	Agency of Observer (e.g., Cornell University, etc.)	40
HC	Comment (should be set to <i>ABC CAMPAIGN</i>)	60
HM	Marker Name (city and country where receiver is sited)	60
HN	Antenna number (serial number or number marked on antenna)	20
HO	Observer's Name	20
HT	Antenna type (may be omitted, defaults to <i>M/A-COM ANP-C-114</i>)	20

You should set the header comments to appropriate values for your station. Note that the “Characters”

column specifies the maximum number of characters allowed in the given header block.

Lastly, the *DX* command at the end of the example *CMD.INI* file is a delayed execution command. This command will be executed at approximately the specified UT time. In this example, the *CF* command (execute command file) runs the command file *STOPLOG* at 1100 UT to stop all data logging. *Important: Do not use delayed execution to start scintillation logging or RINEX2 logging if the station must automatically restart after a power failure. Instead, use the SL and RN 30 commands directly in the CMD.INI file.*

In the *GPSBLDR2.CFG* file, only one parameter, the time offset, will normally need to be modified. (The other two parameters, IRQ number and DMA channel only need to be changed if the hardware settings have been changed.) The time offset is the third line in the file and is marked by a comment. With the computer's internal clock set to local time, the time offset should be set to the difference between local time and Universal Time (UT). If UT is ahead of local time, the time offset should be negative. For example, US Eastern Standard Time lags UT by five hours, so a station set to local time in New York state should have its time offset set to -5 hours. If the computer's time is set to UT, the time offset should be set to zero.

In addition to setting the time offset, make sure that the computer's internal time and date are set correctly. Use the *DATE* and *TIME* commands in DOS to set the computer's clock. *If the computer's time is not set to within a few minutes of the correct time, the GPS software will take a long time to find the satellites' signals.* This delay in signal acquisition occurs because, with an incorrect computer clock setting, the program will predict incorrect satellite positions, and therefore incorrect Doppler shifts, for the signals. Once the receiver acquires some satellite signals, though, the program can correct any offset in the computer's clock.

Finally, in order for the *SCINTMON* program to restart automatically following the loss and subsequent restoration of electrical power, the following lines must be added to the end of the *AUTOEXEC.BAT* file:

```
CD C:\SCINTMON
SCINTMON
```

Also, as discussed above, the *SL* and *RN 30* commands should be added to the end of the *CMD.INI* file to restart data logging.

Running the Program

The *SCINTMON* program should only be run under DOS, not Windows. Change to the *C:\SCINTMON* directory on the computer. Type *SCINTMON* to start the scintillation Monitor program. The program should perform some initial hardware tests, clear the screen and show the F3 display (see **Appendix**) as it begins to search for and lock onto the available GPS satellites' signals. In the middle rows of the screen, the F3 display shows which satellites are currently being tracked on each of the 12 channels of the GPS card. Among the important status indicators on this display are the lock indicators (next to last column, entitled "Locks") and the carrier-to-noise ratio figures (last column, entitled "C/No"). Within a few minutes after startup, at least one of the channels should show the symbols "CCBF" in the "Locks" column and fluctuating numbers (typically around 30-40) for carrier-to-noise ratio.

Once the receiver has locked onto a few satellites and downloaded some navigation information from them, the program should shortly begin computing a GPS navigation solution, consisting of the position of the antenna and offset of the system clock from GPS time. When this occurs, a line near the bottom of the display should state “3-D GPS NAVIGATION IN PROGRESS.” This line is the status line and is used for the display of messages for the operator. In addition to the statement on the status line, the “SVs” display at the top of the top of the screen should be non-zero, the “Nav” display (just below “SVs”) should indicate “3D” and the position (“Lat”, “Lon”, “Hgt”) and speed (“Spd”, “Hdg”, “ROC”) displays should show continuously changing numbers. Finally, the “OscErr” should converge toward some non-zero value. Once the “OscErr” value (local oscillator error in parts per million) has stabilized, the receiver is synchronized to GPS system time and scintillation logging can begin.

Controlling the Program

The SCINTMON program, as also the GPSBLDR2 program, is controlled in two separate ways. First, the function keys, F1–F12, control which text display is shown. (On some computers, F11 and F12 do not work with the SCINTMON/GPSBLDR2 programs, so you must simulate these key presses using the *FK* command discussed below.) The **Appendix** illustrates some of the more useful displays. The channel status display, or F3 display, is the default display shown on startup.

In addition to function key control, the software is also controlled by two letter commands, examples of which include the commands in the CMD.INI file. In order to get into command mode while running the receiver software, press the Esc key. A prompt (“>”) then appears on the bottom line of the display and you may begin typing the command. Use the Back Space key to erase any mistakes and press the Enter key to start the command. To get out of command mode, press the Back Space key until the “>” prompt disappears.

The F1 display (not shown in the **Appendix**) is a help display and lists all of the valid commands except the commands to set header blocks (HA through HT in the software setup section). A short summary of useful commands is given below:

QA	Quit the program after saving the current satellite almanacs to the ALM.INI file. Always use QA rather than QU to ensure that the almanacs get updated.
CF filename	Execute commands from a file. Only one command per line is allowed. Invalid commands or commands with improper syntax are ignored.
DX hh:mm cmd	Delayed command execution. Execute cmd at hh:mm UT. Up to four commands may be pending at a given time. Use the F9 display to see a list of pending commands.
DQ n	Remove command number n (0–3) from the delayed command list. See the F9 display for the numbered list of pending commands.
FK n	Simulate pressing function key n (1–12) to select a display. Useful in command files, in delayed commands or when the software does not recognize F11 and F12 on a particular computer.
ST id	Set the current station ID character (A–Z or 0–9) used in FSL and RINEX

filenames. To view the current station ID character (as well as the header blocks) select the F6 display.

EM x.x Set the elevation mask to x.x degrees. That is, satellites with elevations below x.x degrees will not be used in navigation solutions or have their information saved in log files.

IP posn string Set the initial position of the receiver to posn string (see software setup section). Usually only used in CMD.INI file. Initial position should be set to within one degree.

RN n Log RINEX2 data at n second intervals. RINEX files are text data files in a standard format. Two types of RINEX files may be saved using the GEC Plessey software: (1) observation files (distances, actually “pseudoranges,” to satellites and other measurements), and (2) navigation files (satellite ephemeris data and other parameters). Note: in the current version of the SCINTMON program, RINEX2 observation files are not saved. Only observation files use the n parameter; navigation files do not. Effectively, then, use RN n ($n \neq 0$) to start RINEX navigation file logging and RN 0 to stop RINEX logging. The F7 display shows the current status of RINEX data logging.

SL Toggle scintillation logging (i.e., enter SL to start data logging; then enter SL again to stop data logging). Scintillation logging saves many parameters to disk in a proprietary binary format, including 50 samples per second of satellite signal strength data. If the receiver has just started up, scintillation logging will not begin until the receiver has started computing a navigation solution and the receiver’s clock error (“OscErr”) has converged to a constant value. The F6 display shows the current status of scintillation logging operation.

For other valid commands, see the GPS Builder–2™ Designer’s Guide.

Daily Operation

The following daily routine should be adhered to for the field campaign, once the station has been set up and running for a day:

- 1) Before quitting the SCINTMON program in the morning, use the F5 display (see **Appendix**) to look at the number of missed accumulations. Log the number of missed accumulations. Also log the oscillator error (“Osc Err” in upper right hand corner of F3 display).
- 2) Quit the SCINTMON program with the QA command. Log the time that the program is exited.
- Note whether any power interruptions occurred during the night for the daily log. Use the DOS command DIR *.FSL and look for multiple files on the UT date corresponding to the previous night. Multiple files indicate power interruptions. Note that power failures may leave incomplete files on the disk which need to be repaired *immediately* with the DOS SCANDISK utility.

- 3) Generate a summary file of the scintillation activity. The program SUM.EXE is used to generate the summary file. The command is SUM *file ID*, where *file* is the prefix (name minus the .FSL suffix, *yyymmddIn* format see software setup section under the ST command) of the file you wish to investigate and *ID* is the single character site ID (i.e. I). SUM with the filename *yyymmddIn.sum* that contains the satellite position, scintillation index, and signal power for each satellite in view at one minute intervals. The resultant summary file is small and transportable (~150kB). Cornell University expects a copy of the summary file from each station for every day in which the scintillation monitor was active.
- 4a) Using the supplied MATLAB files (spow.m and selaz.m) generate summary plots of the scintillation activity. spow.m generates a plot of the signal power for each satellite. selaz.m generates an elevation/azimuth plot of the satellites' trajectories along with a bubble-like indicator of the magnitude of scintillation activity. The figures generated by spow.m and selaz.m should be archived by either printing them out or exporting the files to jpeg's (an option in MATLAB).
- 4b) Optionally, use the SCANFILE command to inspect the contents of the night's data files. The syntax of the command is SCANFILE *file*, where *file* is the prefix (name minus the .FSL suffix, *yyymmddIn* format see software setup section under the ST command) of the file you wish to scan. The SCANFILE command uses both the RINEX navigation file and the FSL file. Note any unusual events especially those that appear to be scintillations in the daily log by time, position in the sky and satellites affected.
- 5) Backup the previous night's files using the Adaptec software. (or your own software) . Name backup sets according to the following convention: *YYMMDD_sitename_BACKUP*, where *YY*, *MM*, *DD* are the two digit year, month and day that logging stopped and *sitename* is a one-word name for the site. For example, the backup set from Ancon for the log files which stopped on 03 October 2001 would be named 011003_ANCON_BACKUP.
- 6) Before starting the program in the evening, delete the oldest *.FSL and *.N files which have been backed up to tape. Ensure that the hard drive has about 250 MB free for new files.
- 7) Start SCINTMON approximately two hours before local sunset. Start RINEX2 data logging with the RN 30 command and FSL file logging with the SL command. Note the time the program was started in the daily log.
- Once the oscillator error has stabilized, and FSL logging has started, note the value of oscillator error on the daily log.
- Make sure that the SCINTMON program is tracking satellites (use the F3 display) before you leave the station unattended. If the receiver has not picked up enough satellites to begin a navigation solution within about 10 minutes, something is wrong. Investigate and report the results in the daily log.

Unattended Operation

Using the *DX* and *CF* commands, SCINTMON can operate unattended for a few days in a crude fashion for weekend or holiday operation. The primary limitation on unattended operation is disk space.

A typical installation on a computer with a 1 GB hard drive has room for 3–4 nights of data (assuming data is to be taken for 12 hour periods).

The sample CMD.INI and associated files in the **Appendix** give an example setup for unattended operation. As discussed in the section on setting up the software, the sample CMD.INI file starts FSL data collection and RINEX2 logging as soon as SCINTMON starts. The *DX* command at the end of CMD.INI runs the command file STOPLOG at 1100 UT, which contains commands to stop both types of data logging. In addition to stopping data logging, the *DX* command in STOPLOG tells data logging to restart at 2200 UT via the commands contained in the STARTLOG file. STARTLOG executes STOPLOG at 1100, and so on, until the operator stops the program.

This procedure for unattended operation works well unless there are power failures or the disk fills up. If power failures occur, some subtle aspects of the SCINTMON program come into play. First, given the recommended autostart configuration discussed in the section on setting up the software, if power goes out and then returns, data logging begins *immediately*. That is, if the power goes out and comes back at 1200 UT in the example above, logging for that day begins at 1200 rather than the programmed 2200 UT (but logging will stop at 1100 UT the next day as planned, unless there are further power failures). Second, the *SL* command is a “toggle,” while the *RN 30* and *RN 0* commands explicitly turn RINEX data logging on and off, respectively. The difference between these two types of commands may lead to unexpected results for some command file setups in the event of power loss.

If power failures occur close together in time, SCINTMON may generate several RINEX navigation files but only one FSL file. While RINEX logging begins immediately, FSL data logging is delayed until the receiver has acquired several satellites’ signals and the receiver’s estimate of its oscillator error has stabilized, a process which usually takes about 5 minutes. Between the time that the initial *SL* command is issued and the time that the oscillator error stabilizes, FSL data logging is in “wait” mode and SCINTMON does *not* open the FSL file. So, if a power failure occurs in “wait” mode, two RINEX navigation files will be generated (the first will be small), but only one FSL file will appear. Furthermore, the numbering sequence of the two types of files will be different. For example, the resulting files may be named 011006A0.N, 011006A1.N and 011006A0.FSL. In this case, the trouble is that the files that go together (011006A1.N and 011006A0.FSL) are numbered differently, and SUM and SCANFILE will not work properly. The only fix is for the operator to delete the small file, 011006A0.N, and to rename 011006A1.N to 011006A0.N by hand. Also, the file numbers can only run from 0 to 9. If too many power failures happen, SCINTMON will lose data because it cannot open any file numbers after 9.

On a final note, the procedures recommended under the section on daily operation need to be modified for unattended operation. At a minimum, the operator should log the names and sizes of files generated for each day during the period when the station ran automatically. We also suggest that the operator examine each data set and make notes prior to backing it up. Of course, after unattended operation for several days, it is extremely important that the operator back up and delete old files since the hard disk will be very full.

Using SUM

The SUM utility allows for the create of summary files. The utility uses an FSL file (*yymmddIn.FSL*) and the associate RINEX2 navigation file (*yymmddIn.N*) to generate the summary file. Note that both the FSL file and the N (RINEX2 navigation) file must be present and have the same prefix for SUM to work properly.

The syntax for SUM is:

```
SUM file_prefix siteID
```

where *file_prefix* is in the format *yymmddIn* (see Setting Up (Software)) and is the prefix of the FSL and N files. Note that SUM uses both the FSL file and the N file, so it is extremely important that these two files exist and cover the same time period. Note that there may be mismatches between FSL and N sequence numbers (the *n* in the *file_prefix* format) because RINEX2 navigation data logging begins immediately whereas FSL data logging waits until the clock error has stabilized. For a case where sequence number mismatches could occur, see the section above on unattended operation.

If you want to generate a summary file from 011016Q0.FSL and 011016Q0.N, for example, enter:

```
SUM 011016Q0 Q
```

The resultant file, in this example has the name 011016Q0.SUM, contains header information about the site and the receiver position and records at one minute intervals that contain satellite position, S4 index (amplitude scintillation index) and signal power for each satellite in view.

Summary files are an excellent way to view the scintillation activity during a nightly run on the scintillation monitor. MATLAB routines can generate figures that show a survey of the signal power from each satellite during the night or an elevation/azimuth plot of the satellites' trajectories along with an indicator of the S4 index.

Using FEXTRACT

The FEXTRACT utility allows for extraction of data from an FSL file. The utility uses an FSL file (*yymmddIn.FSL*) and extract data from it. Possible types of data are 50Hz raw or interpolated signal power, pseudorange measurements or integrated carrier phase measurements. The most commonly extracted data is 50Hz interpolated signal power.

The syntax for FEXTRACT is:

```
FEXTRACT fslfile /[wipc] [start [stop]] > outputfile
```

where *fslfile* is in the format *yymmddIn.FSL* (see Setting Up (Software)) and is the FSL file to extract data from. The option */w* extracts raw signal power data, */i* extracts interpolated signal power data, */p* extracts pseudorange data, and */c* extracts integrated carrier phase data. The option *start* is the start time in GPS time (ahead of UTC by 13 seconds as of 8/18/01) HHMM format and the option *stop* is the stop time in GPS time. Indicating a start and/or stop time only extracts the data within the range of times. The option > *outputfile* forces the output from FEXTRACT to a file instead of to standard output (stdout).

For example, if you want to generate a file, 011016Q0.w02, containing raw signal power data from PRN 2 on October 16, 2001 from 2100 to 2200 GPS time, enter:

```
FEXTRACT 011016Q0.FSL /w 2100 2200 > 011016Q0.w02
```

OR

```
FEXTRACT 011016Q0.FSL /i
```

The resultant file in the first example has the name 011016Q0.w02, contains the raw 50Hz data for PRN 2 with time stamps in decimal TICS (a TIC is 0.0999999 seconds ~roughly 1/10 of a second) and the signal power. Recall that to convert the signal power to dB, use the operation $10 \cdot \log_{10}(S)$, where S is the signal power.

In the second example, the output is sent to standard out (stdout) and contains the *interpolated* 50Hz signal power data for PRN 2 with time stamps in decimal TICS and the signal power.

Using SCANFILE

NOTE: Use of SCANFILE is not required and is simply an option for visualizing the scintillation activity.

The SCANFILE utility allows you to examine the data files after they are collected. It provides a qualitative display of FSL file contents in its default mode. Using SCANFILE, you can diagnose some multipath problems and identify potential scintillations. We recommend that you use SCANFILE on each day's set of files.

The syntax for SCANFILE is:

```
SCANFILE file_prefix
```

where *file_prefix* is in the format *yymmddIn* (see **Setting Up (Software)**) and is the prefix of the FSL file to be scanned. Note that SCANFILE uses both the FSL file and the N file for its graphical display feature, so it is extremely important that these two files exist and cover the same time period. Note that there may be mismatches between FSL and N sequence numbers (the *n* in the *file_prefix* format) because RINEX2 navigation data logging begins immediately whereas FSL data logging waits until the clock error has stabilized. For a case where sequence number mismatches could occur, see the section on unattended operation above.

If you want to view the contents of 011016Q0.FSL and 011016Q0.N, for example, enter:

```
SCANFILE 011016Q0
```

and you will be presented with an azimuth–elevation display like the one shown in the **Appendix**. (*Note that there appears to be a compiler bug which sporadically occurs on Pentium® machines when starting SCANFILE. See the README.DOC file for details and the current fix.*)

The graphical portion of the azimuth–elevation display (left side of the screen) is organized as follows. The large circles indicate various elevations (currently 0°, the 10° “mask angle”, 30° and 60°), and the “+” in the center represents zenith. The positions (azimuth and elevation) of the satellites, relative to the receiver, are indicated by numbers (the PRN, or Pseudo–Random Noise code, number) and “tracks” within the large circles. The program plots positions as if the operator were looking down on the satellites from above the receiver, so that north is at the top of the display, east is to the right, and so on. Each track is composed of small circles along 40 minute segments of a satellite's motion.

Satellite tracks are the key portion of the SCANFILE display. The diameter of the small circles indicates the amount of signal strength variance over a one minute period, relative to the mean value of

signal strength for that period. Note that if the variance is extremely small, portions of the track will seem to disappear. Signal strength variance over one minute intervals can be caused by scintillations or multipath. Again, two features will help you to distinguish scintillations from multipath (as discussed in **Setting Up (Hardware)**). First, multipath variance patterns should repeat from one day to the next. Second, equatorial scintillations and multipath often have slightly different time scales of variation, so that multipath may be filtered out to some extent.

The SCANFILE program adopts the second approach, using a bandpass filter which is tuned to the expected frequency range for equatorial scintillations. This filter may be turned off to assist in diagnosing whether multipath is a problem with a given installation. As a rule of thumb, variance that appears when you turn off the filter, but which mostly disappears when the filter is turned on, is probably due to multipath. Remember, though, that the frequency ranges of equatorial scintillations and multipath overlap somewhat, so large circles in the tracks on the SCANFILE display do not *conclusively* indicate scintillations. Further tests to help determine whether variance is due to scintillations include: (1) several satellites appear to be affected simultaneously along the same magnetic meridian (for field-aligned irregularities), (2) the variance patterns do not repeat from day to day, and (3) a time series plot of the satellite signal strength data looks like scintillations rather than multipath.

The right hand side of the SCANFILE screen is a text window which displays various status information for the program. The top lines display the status of the possible modes of operation for the program (trails, filter, etc., which are discussed below). Below the status lines are the UT time and date for the current plot. Most of the rest of the text window is a listing of the GPS satellites in the current plot, along with their elevation and azimuth at the given time in the data files (here “SV” is used as a synonym for PRN, although the usage is not strictly correct).

Operators may control SCANFILE using simple keyboard commands. The commands are listed below:

Command	Description
a	Toggle auto-pause mode ON or OFF
f	Toggle filter ON or OFF
g	Toggle between azimuth-elevation format and geographic format
h	Help screen —brief summary of all commands
p	Pause display
q	Quit SCANFILE
s	Skip ahead to a specified time
t	Toggle satellite trails ON or OFF

Note that auto-pause status does not appear in the top lines of the text window of the sample SCANFILE display in the **Appendix**, because the illustration comes from an older version of the program.

- Auto-pause makes the program pause automatically at fixed 40 minute intervals. Auto-pause can be useful when you try to document a night’s activity using several “screen snapshots.” By default, auto-pause is turned ON when SCANFILE starts. If you want the program to play through the data without interruption, turn auto-pause OFF.
- The filter helps to identify multipath variance in GPS signal strength as discussed above. By default the filter is ON when SCANFILE starts. Press “f” to toggle the filter OFF and ON if you are trying to diagnose multipath problems.

- In addition to the default azimuth–elevation plot, SCANFILE can also show the satellite ionospheric puncture points (at 300 km altitude) on a “geographic” plot—that is, a grid of 250 km by 250 km squares around the observer. To toggle between the geographic plot and the regular display, press “g.” *Note: the geographic plot routine uses approximations that are only valid near the geographic equator.*
- The help screen lists a table of commands along with very brief descriptions.
- When you pause the display by pressing “p,” you can press any key to continue viewing the rest of the file.
- The “q” command aborts file viewing immediately.
- If you want to skip ahead to a specified time in the file, press the “s” key. The program will then prompt you for the time to skip to (in 24 hour, UT format). Note that this feature is somewhat slow since the program scans through the file sequentially to find the desired time. If the program reaches the end of the file before finding the desired time, it will exit. You can quit a skip—e.g., if you entered an incorrect time—by pressing the “q” key while the skip is in progress.
- The toggle trails (“t”) feature determines whether trails will be erased automatically or not. If trails are OFF (as indicated in the status portion of the text window), the ends of trails will be erased so that only 40 minute segments of each satellite’s track will appear on the variance plot. If trails are ON, trails are not erased, even when the satellite goes below the elevation mask or the satellite’s data momentarily disappears from the file (due to lost lock, etc.). By default, trails are OFF.

Finally, to view time series output of signal strength for a given satellite, use the EXTRACT utility rather than SCANFILE. Type EXTRACT without any arguments at the DOS prompt to display its command syntax. The simplest output format to use is the summary data file (/s option). The summary option produces a two–column output of time (first column, decimal hours UT) versus signal strength (arbitrary units), where signal strength is averaged over one second intervals.

Miscellaneous

Useful equipment to take to remote field sites includes: AC adapter plugs, electrical tape, pocket knife (not too big to carry on an airplane!), compass, elevation measuring tool, Phillips screwdriver, regular screwdriver, pliers, measuring tape, camera, extra lengths of low-loss cable.

Backup tape requirements: approximately two (2) 120 m by 4mm DAT tapes per station for 21 days of operation. Note that 4mm DAT tapes are notorious for jamming in their drives (fortunately this has happened only once in a campaign to date), so having spare tapes is a good idea.

Backup CD-ROM requirements: approximately one (1) standard 650MB writeable CD-R per station for 4 days of operation.

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APPENDIX

CMD.INI File

```
RP N42 26.60 W076 28.90 220.0
IP N42 26.60 W076 28.90 220.0
CH 12
EM 10.0
GM 99.0
ST P
HC ABC CAMPAIGN
HM ANCON OBSERVATORY
HO TED BEACH
HA CORNELL UNIVERSITY
HN 5
SL
RN 30
DX 11:00 CF STOPLOG
4
```

GPSBLDR2.CFG File

```
300 Hexadecimal I/O port address for GPS Builder-2 (TM) card
11 Decimal interrupt level for GPS Builder-2 (TM) card
-05 Time zone of user's PC (0=GMT, -6=CST, -7=CDT, -8=PST, -7=PDT, etc.)
4
```

STARTLOG File

```
SL
RN 30
DX 11:00 CF STOPLOG
4
```

STOPLOG File

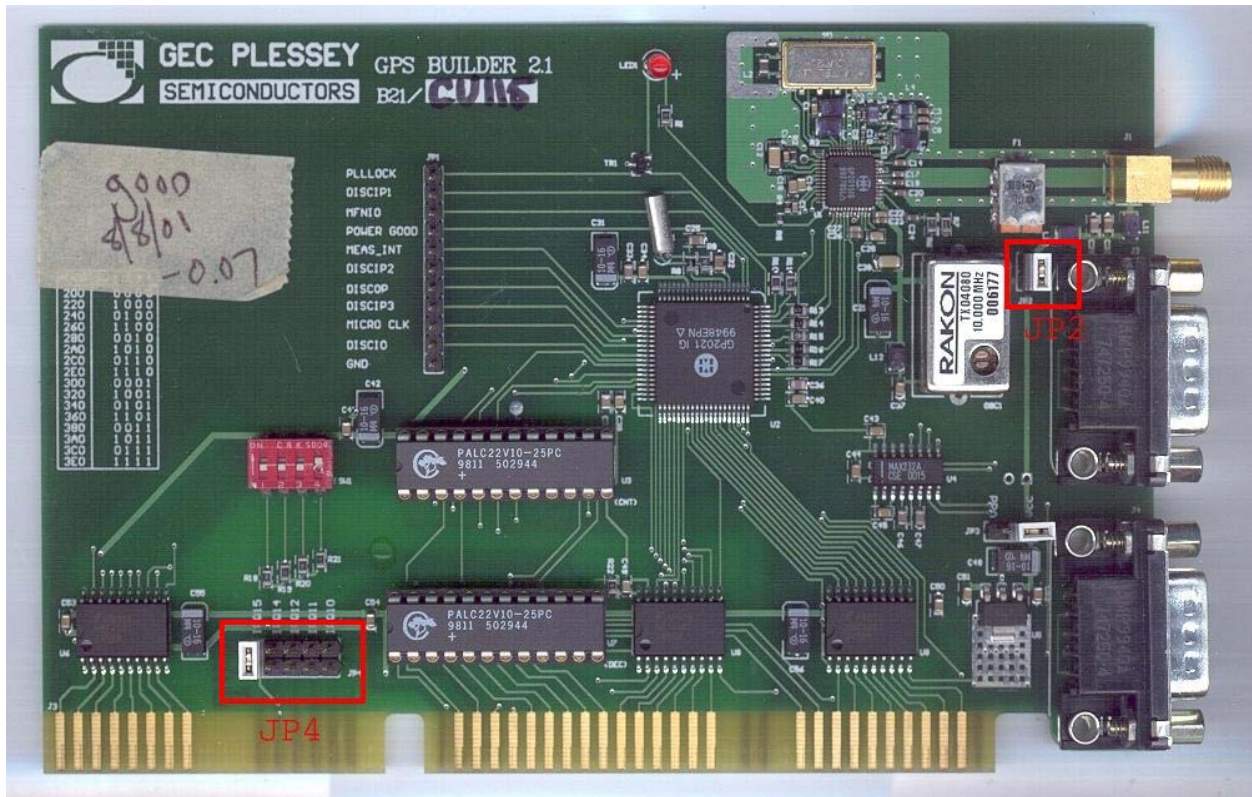


Figure 1. GPSBuilder-2.1 Card with labels indicating jumpers JP2 and JP4

In the above figure, jumpers JP2 and JP4 are indicated by the red boxes. Jumper JP2 determines if the antenna's preamplifier is powered or not. With jumper JP4 inserted, 5V DC is sent to the preamplifier via the center line of the coax and when the jumper is removed, the preamplifier receives no power. Jumper JP4 determines the PC IRQ (Interrupt ReQuest) number to use. Typically, an IRQ number of 10 or 11 will not cause conflict with other devices in the PC.

NOTES