Products: Vector Signal Generator SMIQ

PC Software AlmanacUploader for SMIQ with option SMIQB51 (Digital Standard GPS)

Application Note

This software converts System Effectiveness Model (SEM) almanac files to Global Positioning System (GPS) navigation data as transmitted by GPS satellites, and transfers the data to SMIQ to generate GPS signals in combination with option SMIQB51 – Digital Standard GPS.

ROHDE&SCHWARZ

Subject to change – Dr. Marc Walessa, Dr. René Desquiotz 04/2001 – 1GP46_0E

Contents

1 Introduction

The Global Positioning System (GPS) consists of several satellites circling the earth in low orbits. The position of a receiver on the earth can be determined by carrying out delay measurements of at least four signals emitted by different satellites.

Being transmitted on a single carrier frequency, the signals of the individual satellites can be distinguished by means of correlation (Gold) codes (with GPS, these codes are known as C/A codes). Information on time and satellite orbit is contained in the navigation data emitted by each satellite. In this case, the C/A codes are used as spreading codes (see CDMA) for the navigation data.

Each GPS satellite emits an individual navigation data sequence spread by the C/A code assigned to it at the carrier frequency L1 = 1.57542 GHz. A GPS signal of this type (see Table 1-1 GPS system parameters

), which allows basic receiver function tests to be carried out, can be generated by SMIQ for one satellite.

Table 1-1 GPS system parameters

Carrier frequency	1.57542 GHz
Signal level, after antenna	Approx. –125 dBm to [1] and [2], depending on receive conditions
Doppler shift	-10 kHz to +10 kHz settable
Symbol rate (C/A code)	1.023 Msps
C/A codes	1 to 37 settable, 1023 chips per C/A code
Modulation	BPSK
Information data rate (navigation data)	50 Hz
Frame structure of navigation data	25 frames consisting of 5 subframes where 1 subframe consists of 10 words, 1 word consists of 30 data bits, 1 data bit consists of 20460 C/A code chips.

The C/A code specifies the satellite and is fundamental to the simulation of GPS signals. In addition, navigation data (called “almanac data”) play an extremely important role, since they are essential for calculating the positions of the four satellites, which are the minimum prerequisite for localization purposes. However, even if only one satellite is available (as

simulated by SMIQ), pseudo navigation data can be used to check the decoding of navigation information (such as GPS time, almanac and ephemeris) in addition to the recognition of the C/A code.

Current almanac data can be downloaded via the Internet. The **AlmanacUploader** PC software converts SEM almanac files to GPS navigation data as transmitted by GPS satellites, and transfers the data to SMIQ to generate GPS signals in combination with SMIQ option SMIQB51.

SEM almanac files can be downloaded from the U.S. Coast Guard Navigation Center GPS homepage (http://www.navcen.uscg.gov/ftp/GPS/almanacs/sem/) in ASCII format. From an almanac file the **AlmanacUploader** PC software generates a set of navigation messages, of 37500 bits each, required for consistent GPS signals of 12.5 minutes duration. Important parameters like week number (WN), time of almanac (toa), time of ephemeris (toe), time of GPS week (TOW) and issue of data clock (IODC) can be adjusted. The resulting navigation data bit-streams can be uploaded to SMIQ as data lists, where they can be selected as NAVIGATION DATA SOURCE for the generation of GPS signals.

For further information on the GPS navigation message frame-structure and the influence of the parameters adjustable in this software, please consult the references [1] and [2]. Operation of SMIQB51 is described in [3]. For basic information on GPS, see reference [4].

2 Hardware & Software Requirements, Installation

AlmanacUploader requires Windows NT/95/98 as operating system and a GPIB (IEC/IEEE)-bus card and driver from National Instruments. For installation, copy the three files *AlmanacU.001*, *AlmanacU.002* and *setup.exe* to a directory on your PC. Start the *setup.exe* program and follow the instructions.

To upload converted almanac files to an SMIQ (equipped with option SMIQB51 Digital Standard GPS), connect the PC to the SMIQ with a GPIB cable, as shown in Fig. 2-1 Connecting SMIQ and PC via GPIB.

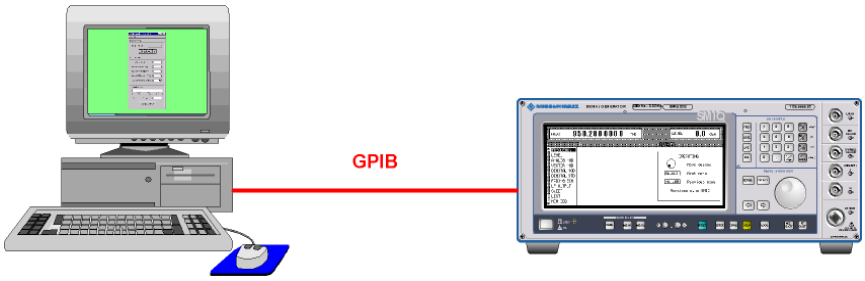

Fig. 2-1 Connecting SMIQ and PC via GPIB.

3 Operating AlmanacUploader

The software is controlled from the main panel, which comprises several buttons, controls and displays. The user can set various GPS-specific parameters which are used for the generation of customized GPS navigation messages.

Controls and displays on the main panel

Selected Almanac:

Displays the currently selected almanac file used for the generation of GPS satellite navigation messages.

Select Almanac File:

Opens a file-selection dialogue where the SEM almanac file to be used can be chosen. *Note: YUMA almanac files are not supported by this software.*

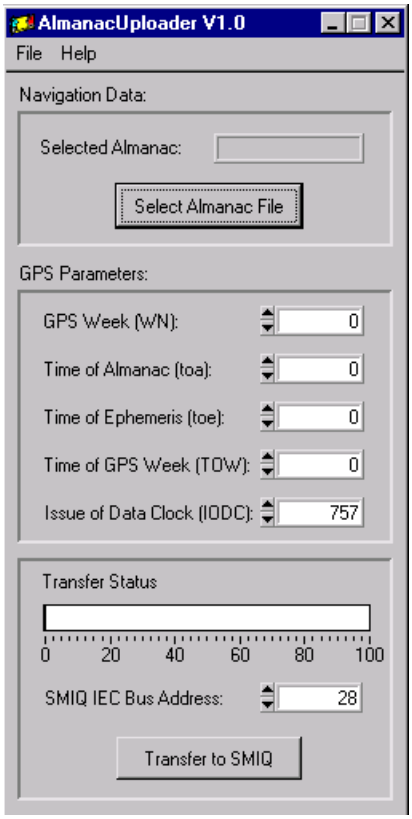

Fig. 3-1: Main panel of AlmanacUploader

GPS Week (WN):

Although already contained in the SEM almanac file the GPS Week (WN) parameter of the navigation message can be modified by the user from 0 to 1023. By default, the value given in the almanac file is displayed.

Time of Almanac (toa):

Allows to specify the Time of Almanac (toa) from 0 to 604799 which determines the reference time of the almanac data. By default, the value given in the SEM almanac is displayed.

Time of Ephemeris (toe):

Allows to specify the Time of Ephemeris (toe) from 0 to 604799 which determines the reference time of the satellite-specific ephemeris data. In contrast to the real case, this value is identical for the navigation messages of all satellites. By default, the toa-value given in the SEM almanac is selected.

Time of GPS Week (TOW):

Allows to specify the Time of GPS Week (TOW) from 0 to 604799, i.e. the time of simulation. The TOW is partly contained in each Hand-Over Word (HOW) of the navigation message and is incremented by six seconds with each subframe. *Note: After transmission of the whole navigation message (12.5 minutes), the TOW restarts from its original value due to cyclic repetition of the GPS signal. By default, the next valid value close to the toa-value of the SEM almanac is displayed. For proper functioning, the chosen value should be a multiple of 30.*

Issue of Data Clock (IODC):

Allows to change the value of the Issue of Data Clock (IODC). This can be useful if you want your GPS receiver to employ the currently sent almanac and ephemeris data. These data are updated contingent on a different IODC value compared to the one of a previously received navigation message. By default, a value of 757 is used.

Transfer Status:

Indicates the transfer status from PC to SMIQ of the generated navigation messages. Since 32 lists (corresponding to the first 32 C/A codes) with 37500 bits each (=1200000 bits) are transferred at maximum, the upload will take only a few seconds. *Note: Switch OFF the modulation STATE of the SMIQ prior to upload.*

SMIQ IEC Bus Address:

Allows to select the IEC Bus address of your SMIQ. Please make sure that the correct value is chosen, otherwise transmission will not work. By default, a value of 28 is employed.

Transfer to SMIQ:

Starts the computation of the navigation messages and transmits the bit-streams to the SMIQ. The resulting data lists in the SMIQ are named “NAVDAT##”, where ## stands for the number of the simulated satellite. *Note: All data lists in the SMIQ corresponding to this naming convention, i.e. “NAVDAT01” to 32, are deleted prior to upload in order to ensure consistent navigation messages from one single almanac file.*

Please consult the references [1] and [2] for more details on the GPS-specific parameters.

Menu Structure

The menu structure of the main panel comprises the following basic options:

File Menu:

Quit:

Quits the “AlmanacUploader” software tool after confirmation by the user.

Help Menu:

About:

Provides some basic product information.

4 Generating a GPS signal with valid Navigation Message

This section shows how GPS navigation messages are created and transmitted to SMIQ with the **AlmanacUploader** software. The subsequent GPS signal generation on SMIQ is also illustrated. For operation of SMIQB51, see reference [3].

Downloading a SEM Almanac

Download a valid SEM almanac file from the U.S.Coast Guard Navigation Center GPS homepage (http://www.navcen.uscg.gov/ftp/GPS/almanacs/sem/). These files are in ASCII format. *Note: YUMA almanac files are not supported by this software.*

Computing Navigation Messages and uploading to SMIQ

Start the **AlmanacUploader** software and select the downloaded file after clicking on the “Select Almanac File” button. The currently selected file is displayed above.

According to the contents of the almanac file the GPS parameters WN, toa, toe, TOW and IODC are set to their default values. You may freely adjust these values. However, a consistency check of your changes is not performed.

With the modulation STATE of the SMIQ switched OFF, press the “Transfer to SMIQ” button in order to upload the generated navigation messages after having verified the SMIQ IEC bus address. The number of transferred lists is determined by the number of satellites described in the almanac file. After upload the corresponding data lists “NAVDAT##” are available in the SMIQ.

Generating GPS signals with Navigation Data on SMIQ

Set the satellite and the RF and power settings to their defaults. Select a desired Doppler shift and adjust the C/A code you want to use. Switch the NAVIGATION DATA SOURCE to DATA_LIST and select one of the data lists named “NAVDAT##”.

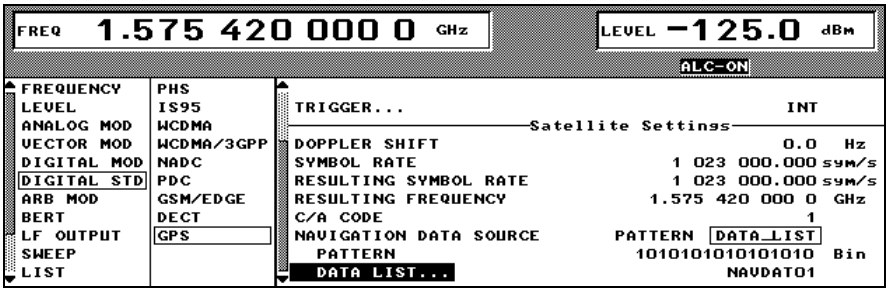

Fig. 4-1 Selecting navigation data in the SMIQB51 menu.

In principle, the numbers of the selected C/A code and of the selected navigation list should coincide (e.g. C/A code 3 and NAVDAT03). However, since only the signal of one satellite is generated, this assignment is not imperative. You can freely mix C/A codes and navigation messages to generate valid GPS signals.

Finally, switch the STATE from OFF to ON to physically output the GPS signal.

5 References

[1] Interface Control Document ICD-GPS-200.

[2] Global Positioning System Standard Positioning Service Signal Specification, 2nd Edition, 1995.

[3] Vector Signal Generator SMIQ, Operating Manual, PD 1125.5610.12, Rohde & Schwarz, 2001

[4] GPS Guide for Beginners, Part No 190-00224-00 Rev. A, Garmin Corporation, 2000

6 Ordering information

Vector Signal Generator:		
SMIQ02B	300 kHz to 2.2 GHz	1125.5555.02
SMIQ03B	300 kHz to 3.3 GHz	1125.5555.03
SMIQ04B	300 kHz to 4.4 GHz	1125.5555.04
SMIQ06B	300 kHz to 6.4 GHz	1125.5555.06
Options:		
SMIQB11	Data Generator	1085.4502.04
SMIQB12	Memory Extension	1085.2800.04
SMIQB20	Modulation Coder	1125.5190.02
SMIQB51	Digital Standard GPS	1105.1683.02

ROHDE & SCHWARZ GmbH & Co. KG · Mühldorfstraße 15 · D-81671 München · P.O.B. 80 14 69 · D-81614 München ·
Telephone +49 89 4129 -0 · Fax +49 89 4129 - 13777 · Internet: http://www.rohde-schwarz.com