Ball
Efratom
Elektronik
GmbH

OPERATION MANUAL

M G P S

RECEIVER / CONTROLLER SYSTEM

- Software Versions 0174 + -

SERIAL NO.:		SOFTWARE VERSION:	
USER DELAY:		AUX-CALIBRATION:	
ANT. PART NO.:	PN	ANT. SERIAL NO.:	SN
ANT. CABLE TYPE:		ANT. CABLE LENGTH:	

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Document Scope

The Ball Efratom Modular Receiver/Controller Model MGPS has been designed to receive GPS transmissions and to interface with the Ball Efratom MRK Modular Rubidium Oscillator module to generate precision time and frequency signals.

The MGPS module is designed to be inserted into the prewired mainframe of a Ball Efratom Modular Frequency System (MFS) along with the MRK and other modules. Each module is supplied with its own manual.

This manual provides operating information for the MGPS.

Please note the floppy disk that is enclosed with the MGPS package.

This diskette provides the software utility for using the RS-232 Interface. Further, it provides latest operating information (README.TXT) that was not available when generating this documentation.

TABLE OF CONTENTS

0. GENERAL SAFETY PRECAUTIONS

The following general safety precautions must be observed during all phases of the operation of this instrument. Failure to comply with these precautions violates safety standards of design, manufacture, and intended use of the instrument. Efratom assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument must be connected to an electrical ground. The instrument uses a three-conductor ac power cable. The power cable must either be plugged into an approved three contact electrical outlet, or used with a three-contact to two-contact adapter with the grounding wire firmly connected to an electrical ground (safety ground) at the power outlet.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel should not remove instrument covers. Component replacement and internal adjustments should be made by qualified personnel. Do not replace with power cables connected. To avoid injuries, always disconnect power from the unit.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts, or perform any unauthorized modification to the instrument. Return the instrument to Efratom for service and repair to ensure that safety features are maintained.

1. POWER UP

The following passages will give a brief information on the sequence of events that will start as soon as the system will be supplied with power and control signals.

To toggle through the information menus/displays, use keys ⇧ and ⇩.

See **sections 6. Display Menus** and **7. Maintenance / Troubleshooting** for further information.

1.1.

First, the MGPS will start to "Warm up". **The "Warm up" will take a maximum of 15 min.**

During "Warm up" the System will start to count Time, Date, Day of Year, and Modified Julian Date (MJD) as shown on the right side (Display: Main Menu).

During "Warm up" the identification numbers of the satellites used for positioning will be displayed in the Position menu.

As the MGPS has been factory-set to the Stationary Mode, the displayed "Mode" will be "Stat".

The GPS Receiver Status may be displayed like:

"No satellites usable"
"Only 1 usable sat."
"Only 2 usable sat."
"PDOP is too high"
"Don't have GPS time"
"Waiting for almanac"
"Normal operation"

If other (error) messages occur, see sect. 7. Maintenance / Troubleshooting.

Main Menu

```
TIME: 00:00:00          TFOM: -
DATE: 00-01-01           D: 1
MJD:          0    MODE: Stat
STATUS: Warm up
```

Position Menu

```
LAT:
LON:
ALT:                MODE: Stat
SV#: ##   ##
```

GPS Receiver Status Menu

```
GPS RECEIVER STATUS:
Only 2 usable sat.
ACT. DELAY: ----------
```

...

1.2.

After a maximum of 15 minutes of "Warm up" the display will change to "Warm up ended". This means that the system has booted without problems.

Calculated positions and identification numbers of the satellites (SV; Space Vehicles) used for positioning (max. 4 sat.) will be displayed in the Position Menu.

The GPS Receiver Status may be displayed like:

"No satellites usable"
"Only 1 usable sat."
"Only 2 usable sat."
"PDOP is too high"
"Don't have GPS time"
"Waiting for almanac"
"Normal operation"

If other (error) messages occur, see sect. 7. Maintenance/Troubleshooting.

Main Menu

```
TIME: 00:15:57          TFOM: -
DATE: 00-01-01           D:1
MJD:          0     MODE: Stat
STATUS: Warm up ended
```

Position Menu

```
LAT: ##°##.###' N
LON: ##°##.###' E
ALT: +/- ### m        MODE: Stat
SV#: ##   ##   ##   ##
```

GPS Receiver Status Menu

```
GPS RECEIVER STATUS:
Normal operation
ACT. DELAY: ----------
```

...

1.3.

As soon as "Locked to GPS" is displayed, TIME and DATE are updated by GPS.

It will take about 8 minutes to provide a first ACTUAL DELAY; in case of poor satellite availability (e.g. No satellites usable, Only 1/2 usable sat., PDOP is too high, Waiting for almanac) this process may last up to 3 to 4 hours.

The MGPS is using averaging algorithms to compensate for the effects of SA (Selective Availability).
The precise position data of the antenna location will have been determined after 24 hours of operation.

Main Menu

```
TIME: 13:25:57          TFOM: 4
DATE: 92-08-27           D: 239
MJD: 48861          MODE: Stat
STATUS: Locked to GPS
```

Position Menu

```
LAT: ##°##.###' N
LON: ##°##.###' E
ALT: +/- ### m          MODE: Stat
SV#: ##   ##   ##   ##
```

GPS Receiver Status Menu

```
GPS RECEIVER STATUS:
Normal operation
ACT. DELAY:          +/- ###.## ns
```

2. INTRODUCTION

THE GLOBAL POSITIONING SYSTEM (GPS)

GPS is a satellite-based radio navigation system designed by the US Department of Defense to provide continuous velocity, timing and three dimensional positioning information on a global basis.

For global coverage with 4 satellites in view the system requires a minimum of 18 satellites in 6 different orbits forming a "birdcage" approximately 10,000 miles above the earth. Each satellite circles the earth twice a day in a 12 (sidereal) hour orbit.

However, 4 satellites are only necessary on a continuous basis when navigating. Having determined position only one satellite is required to establish and maintain precise timing.

Since the accuracy of any position fix or velocity computation is directly proportional to the accuracy of the time reference employed, precision timing is a key element of the GPS concept. This is reflected by the precise time and frequency information provided by encoded data transmissions from each satellite.

Each satellite transmits uniquely coded signals derived from a precision on-board clock which enables a receiver to determine the distance to the satellite by measuring the signal time of arrival. Since the satellite broadcasts its own position data the three position dimensions and the receiver clock bias can be solved by simultaneously tracking four satellites.

The positions of the GPS satellites and the baseline vector are referenced to the World Geodetic System 1984 (WGS84).
Satellite data transmissions include orbital parameters describing the satellite position and connecting the positions in the orbital coordinate system to positions in the Conventional Terrestrial System (CTS).
The CTS is defined as having its origin at the mass center of the earth, its *z*-axis aligned with the mean spin axis of the earth, and its *x*-axis pointing toward the mean meridian of Greenwich. The *y*-axis is defined by assuming a right-handed, orthogonal system.
The satellite positions and the coordinates of the unknown receiver/antenna location on the earth's surface are therefore given in a three-dimensional Cartesian coordinate frame as defined by a particular realization of the CTS.

The coordinates are transformed from Cartesian to curvilinear systems by defining an ellipsoid of revolution that has its origin at the mass center of the earth and has its axes coincident with those of the CTS. Standard geodesy documents contain the formulas for transforming the Cartesian coordinates into geodetic coordinates - latitude, longitude, and ellipsoidal height.

WGS84 defines the reference ellipsoid and the realization of the Conventional Terrestrial System (CTS) presently used for GPS work. The positions directly derived from GPS measurements are ellipsoidal positions given in the CTS and referred to the ellipsoid defined by WGS84.

All GPS satellites transmit codes on two L-band frequencies (L1 and L2). The secure precision (P) and coarse acquisition (C/A) codes are transmitted on the L1 frequency (1575.42 MHz). The L2 frequency (1227.6 MHz) is used for P code only. Access to the P code is restricted to authorized users.

All commercial receivers operate on the C/A code. A ground based system of antennas, master control stations, and monitor stations track the satellites through their broadcast signals as the satellites rise over the horizon. Data is uploaded at least once a day to provide a prediction of satellite ephemeris (orbital characteristics) and clock behaviour for the next day's operation.

The precision of the GPS Master Control Station is traceable to UTC through the time standards at the United States Naval Observatory, USNO, Washington and the United States National Institute of Standards and Technology, NIST.

The Ball Efratom GPS Receiver / Controller Module Model MGPS has been designed to receive the L1 C/A coded signals from the GPS satellites. It will automatically compute its position and then determine and maintain precise timing.

TIME SCALES, GPS and the MGPS MODULE

The signals transmitted by GPS satellites are referenced to *GPS SYSTEM TIME (GST)*, which derives from a "paper" clock consisting of all operational monitor station and satellite clocks.

The *Coordinated Universal Time, UTC,* distributed by the GPS satellites is traced to the United States Naval Observatory (USNO).

While *UTC(USNO)* is kept in coarse agreement with the earth's rotation by insertion of leap seconds (LS), GST does not follow this scheme. GST is consequently ahead of UTC(USNO) by an integer number of seconds, LS.

GST is steered towards UTC(USNO) to keep the difference (apart from LS) to a minimum, k. The parameters to calculate LS and k plus information about future leap seconds, LS, are included in the navigation message transmitted by the satellites.

$$UTC(USNO)^{*)} = GST - LS - k$$

The UTC Time derived from the *1PPS OUTPUT* of the MGPS module, *UTC(MGPS)*, equals *UTC(USNO)* *) plus a value for a *USER DELAY.*
This *USER DELAY* is used to calibrate the MGPS for an accurate 1PPS output and can be set by the operator in order to shift the 1PPS output signal of the MGPS module, for example to compensate for the antenna cable length (see also page 28).
The leading edge of the MGPS 1PPS output signal indicates the beginning of a UTC(MGPS) second.

$$UTC(MGPS) = UTC(USNO)^{*)} + USER\ DELAY$$

*) as transferred via GPS

The *1PPS INPUT* of the MGPS module can be used for time tagging an applied pulse (leading edge) derived from an external timing source.

The measured values are displayed in the AUXILIARY INPUT MENU (see page 24).

The *CURRENT AUX. DELAY (AUX. DELAY)* indicated at the MGPS display, corresponds to the timing pulse (leading edge) of the external timing source connected to the *1PPS INPUT*, minus *UTC(MGPS)* and plus the value of an *AUX-CALIBRATION* that can be programed by the operator.

$$AUX.\ DELAY = 1PPS\_IN - UTC(MGPS) + AUX\text{-}CALIBRATION$$

3. SPECIFICATIONS

Antenna/Preamplifier

Frequency:	1565 - 1585 MHz
Polarization:	Right-hand Circular
Gain:	40 - 55 dBi
Output VSWR:	< 2:1
Connector:	N type female
Dimensions:	Height: 84 mm Diameter: 145 mm
Operating Temperature:	-55°C to +85°C

Antenna Cable

Type:	RG213/U
Length:	25 m
Loss:	≤ 10 dB
Connectors:	N type male
	Direct current is carried up to the antenna preamplifier on the central conductor of the cable and GPS signals are carried from the antenna to the Receiver/Controller.

Receiver/Controller Module

Receiver Input:	1575.42 MHz (L1) C/A Code
Timing Accuracy:	100 ns rms*)
Frequency Accuracy:	1E-12 rms*)
Position Accuracy:	25 m rms*)

*) Includes Selective Availability (S.A.) as described in the TECHNICAL CHARACTERISTICS OF THE NAVSTAR GPS document published in June 1991 by the NAVSTAR GPS Technical Support Group. Assumes 24h continuous operation in a fixed stationary position with temperature changes of less than +/-2°C/day. Subject to sufficient satellite availability.

(cont.)

Display:	LCD type, 4 lines, 20 characters per line, displays UTC time of day, Day of Year and calendar date, Modified Julian Date, latitude, longitude, altitude (WGS84), frequency offset, control voltage, etc.
Keypad:	6 pushbuttons and keylock switch
1PPS Input:	For time tagging of an applied pulse (leading edge) of an external time/frequency source. Measured value (1ns resolution) is displayed at the AUXILIARY INPUT MENU (see page 24, section 6.4.).
1PPS Output:	This signal will be TTL compatible, 3.75v +/- 1.25v for logic "1", and 0.4v +/- 0.4v for logic "0" into 50 ohm impedance. The leading edge of the positive going "one" pulse, will be time coherent with the relevant UTC second pulse as received by the GPS receiver within max 100 ns*). The rise time will be max. 10 ns. Jitter on leading edge will be max 10 ns. Length of pulse will be minimum 7 µs.
Connectors:	N type female (antenna), BNC for 1PPS signals, D9S (RS 232).
Operating Temperature:	0°C to +50°C

*) see page 7

RS-232 Port: 9.600 Baud, 8 bit word length, 1 start bit,
2 stop bits, no parity, (hardware handshake).
(See page 29 "6.11. RS-232 Interface Menu" for RS-232 settings).
The software utility to be used is provided by a floppy disk and is enclosed with the MGPS package.

Provides:

- **Actual Time**
- **Day of Year**
- **Modified Julian Date**
- **Position**
  - Latitude
  - Longitude
  - Altitude
- **History**
  - Date and time of Synchronization by GPS
  - Date and time of Time transferred by GPS
  - Date and time of Time correction by GPS
  - Date and time of Freq. correction by GPS
- **Status**
  - Date and time
  - Mod. Jul. Date
  - Power low — Date and time
  - MRK unlock — Date and time
  - MRK locked — Date and time
  - System state
  - Operating mode
  - Control voltage
  - Software version
- **Satellites**
  - Signal level of satellites being tracked
- **Output of Aux Delay Data**
  - Tags date and time of applied pulse (leading edge) with 1ns resolution.
  - (Also displayed at the AUXILIARY INPUT MENU, see page 24, section 6.4.)

4. DESCRIPTION

The GPS Receiver/Controller Model MGPS has been designed to interface with the MRK Rubidium Oscillator Module in the Ball Efratom Modular System to combine the precision of GPS with the stability of a rubidium oscillator. The major elements in the MGPS are shown in Figure 1 MGPS Block Diagram.

The MGPS takes the stable reference frequency from the MRK and generates its own time scale. This time scale can be locked to GPS using the GPS receiver. During periods of no GPS reception or external timing the MRK will provide the necessary "flywheel" to maintain a high degree of accuracy.

The timing output is a 1PPS signal. Optional code generators can be fitted to provide Time of Day (TOD) in the Havequick, Irig and other formats.

In addition to providing precise time the MGPS determines the frequency offset of the MRK by comparing the frequency of the MRK with the timing data received from the GPS transmission. This information is used to discipline the MRK through its "C-field adjust", thus providing an automatic on-line calibration feature.

The frequency stability of the MRK which changes in temperature is significantly improved by the MGPS. The MGPS monitors the MRK base plate temperature and makes the necessary "C-field" adjustments based on the MRK temperature profile stored in its memory (Option).

The MGPS Module is designed to receive the L1 C/A coded signals from the GPS satellites using the Antenna/Preamplifier unit and connecting cables supplied. The MGPS Module will automatically acquire satellites and data to perform the necessary position and timing calculations. The status of the timing output is under the control of the microprocessor and is determined by the validity of the timing data from the MGPS Module. The status and performance of the MGPS is visible on the front panel display. The front panel keyboard is used to select the menu required and to edit the data displayed as appropriate.

Figure 2 shows the GPS Antenna/Preamplifier Unit. This is usually connected to the MGPS Interface Panel using the coaxial cable.

Figure 3 shows the front and rear panel views of the MGPS.

Figure 4 shows the Interface Panels that are necessary to connect external signals to connector P1 on the MGPS.

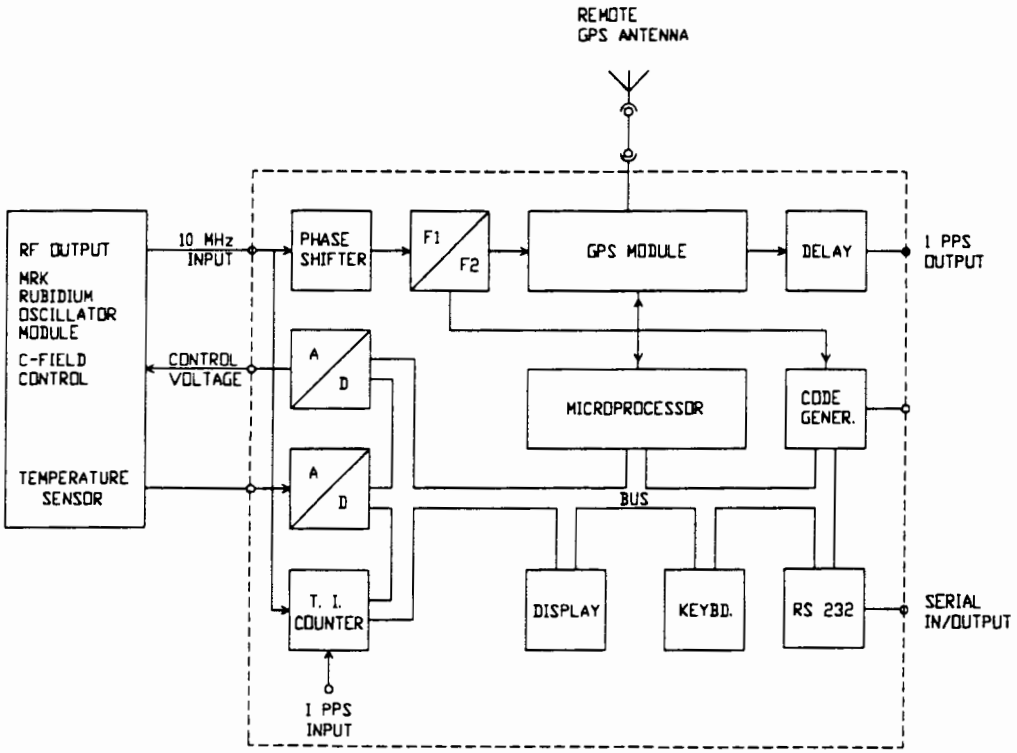


Fig. 1
MGPS Block Diagram

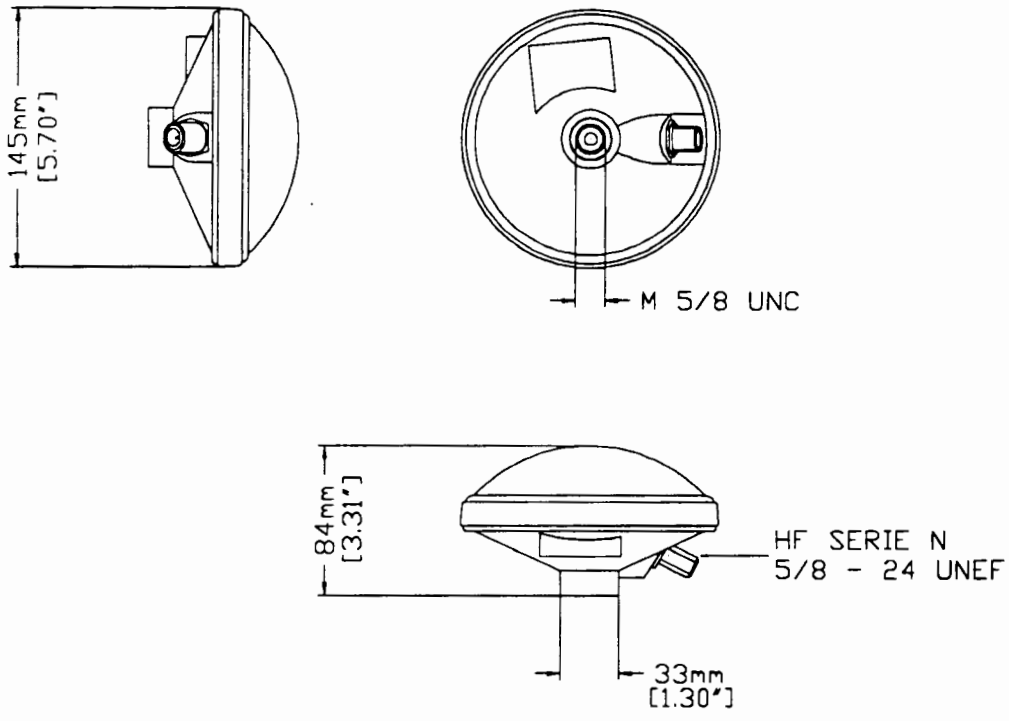


Fig. 2
GPS Antenna/Preamplifier Unit

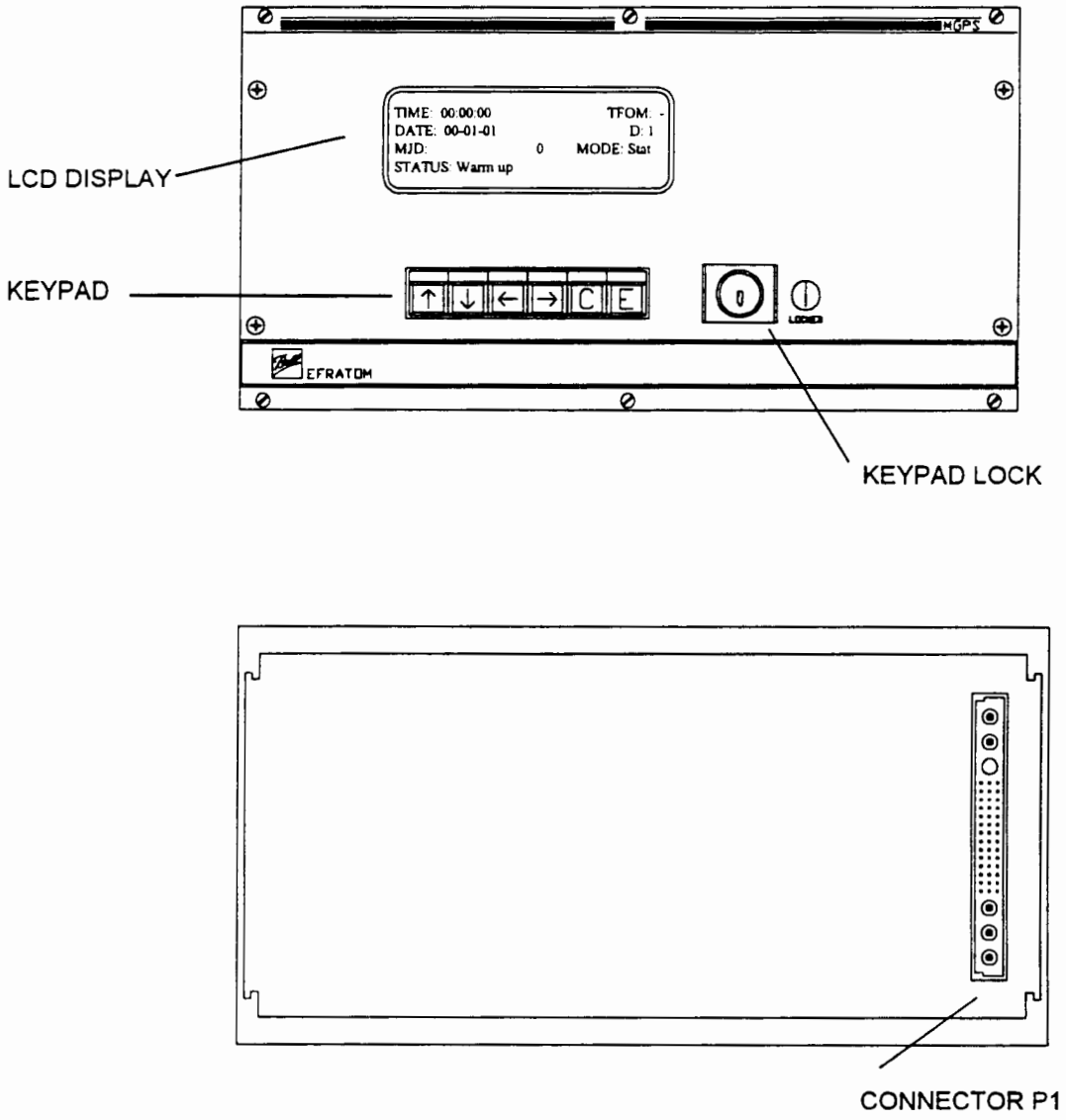


Fig. 3
MGPS Module - Front and Rear Panel Views

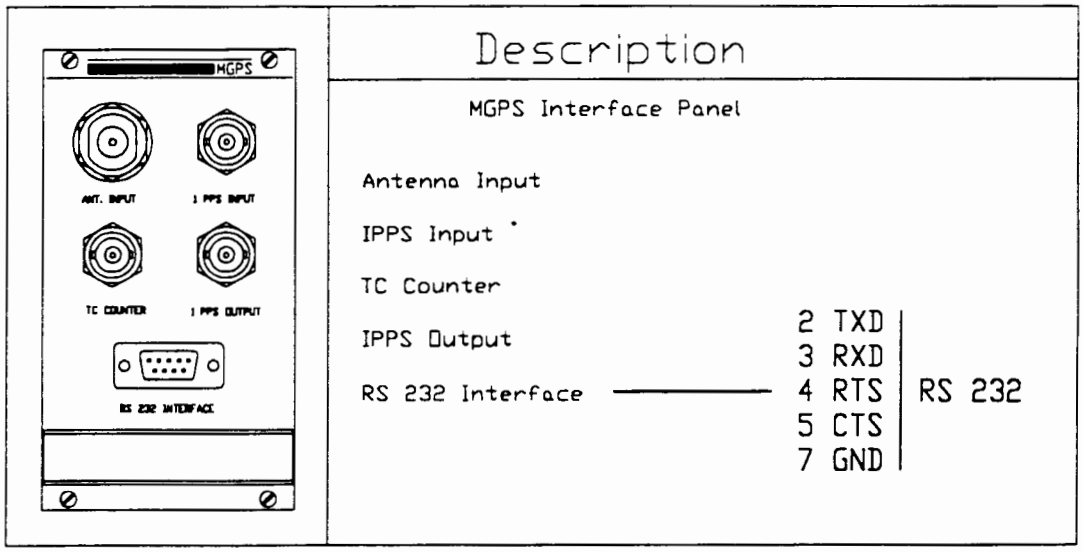


Fig. 4
MGPS Interface Panel

5. OPERATION

The prime function of the MGPS is to interface with the MRK to generate time and frequency signals under the control of GPS.

Before the MGPS can commence its primary function it first has to know its precise location. This data is acquired from the GPS when the MGPS has successfully locked to four GPS satellites. After that, for precise time transfer operation, only one GPS satellite is needed to control the precision of the time and frequency generator.

The MGPS is factory-set to the Stationary mode. During operation of the MGPS in the Stationary mode averaging algorithms are applied to compensate for the effects of Selective Availability (SA).

The Mobile mode is selected when the MGPS is being used for navigation in a moving vehicle. In this mode the MGPS does not use averaging algorithms to determine the current antenna position, but the system performs continuous positioning by directly and only processing the currently received GPS satellite signals.

The procedure for manual switching between the Stationary mode and the Mobile mode is explained in section 6. Display Menus.

The mode selected data is stored in a non-volatile RAM. This ensures that the MGPS will power up in the mode last selected prior to switch off. This RAM is factory-set just prior to shipment to cause the MGPS to power up in the Stationary mode.

The status of the system from the moment when power is applied is displayed on the front panel of the MGPS in the Main Menu. This and other menus are described in the section 6. Display Menus.

Possible changes of System status are illustrated in Figure 5 "System Status Flow Diagram".

The sequence of events which determine the System status are explained in section 1. Power Up and the following sections.

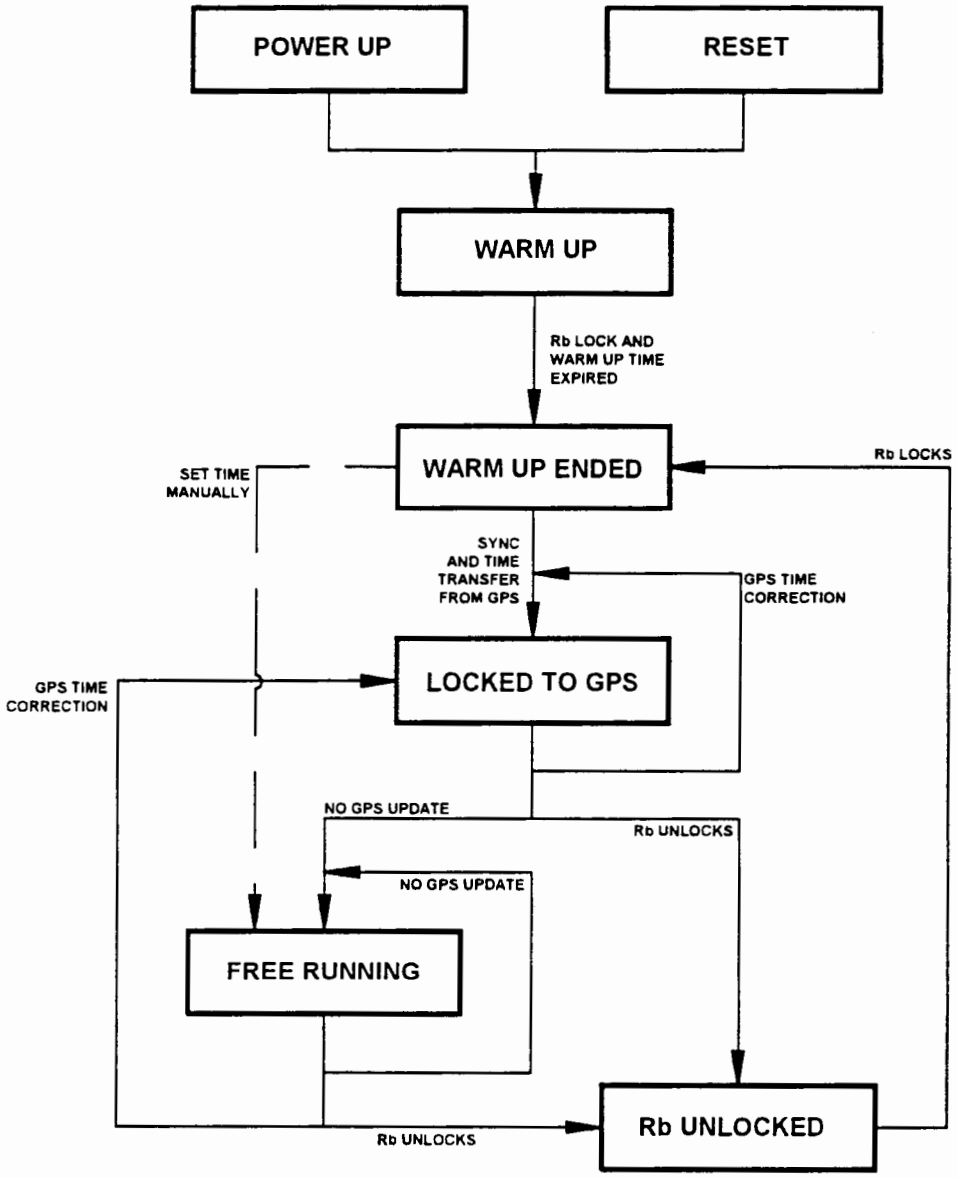


Fig. 5
SYSTEM STATUS FLOW DIAGRAM

Warm up

When power is applied the System will commence a warm up phase determined by the time taken for the MRK to achieve lock, however not lasting less than 15 minutes and providing a valid 10 MHz reference signal to the MGPS.
For further information the MRK manual should be consulted.

Warm up ended

As soon as the MRK reaches the lock status the message "Warm up ended" will be displayed and the MGPS will commence the GPS satellite acquisition phase.

Acquisition of GPS Satellites

The MGPS fix acquisition and tracking process features the ability to determine position without any initialization. The receiver has the ability to track up to 6 satellites providing constellation changes without new satellite acquisition.

The following sections describe the acquisition, tracking, and GPS solutions performance of the MGPS for determining position data.

Upon powering the system, the MGPS will begin a search for satellites that are expected to be above the horizon. This calculation is based on the battery-backed almanac of satellite orbits, an estimate of current position (based on receiver's last calculated fix), and the current time from the self-contained, real-time clock. If this information is reasonably accurate (position within 1000 km, time within 5-10 minutes) rapid acquisition of the available satellites will occur. Once locked, if the elapsed time from the previous fix taken by the MGPS unit is more than one hour, current satellite ephemeris must be collected from the data message of each satellite. Given that the appropriate number of satellites being tracked and the ephemeris data for each satellite is current, the solution of user position and time will be performed.*)

The time required for the MGPS to acquire satellites and calculate position and velocity states is dependent upon a number of factors. Primarily, it will depend on whether the unit has a representative satellite almanac in battery-backed memory, the time elapsed since the previous operating fix, and the distance the unit has been moved since the last operating fix (i.e., where the receiver currently "thinks" it is).

Given the conditions that the MGPS has current almanac, current ephemeris, and has not been moved a great distance (<1000 km) since its last fix, acquisition and position/time solution occur within 1.0 to 1.5 minutes from power-up.

The subsequent paragraphs describe processes that will lengthen time to first fix, the circumstances under which they are required, and the approximate time impact.

*) The software consists of averaging algorithms and is optimized for stationary applications.
When changing the location of the GPS antenna while operating the MGPS be sure to set the operating mode to "Mobile" while moving and back to "Stationary" to start a new averaging process for the position of the new antenna site.

Almanac

The satellite almanac consists of approximate orbit parameter data to aid the MGPS in satellite acquisition. This data is held in battery-backed RAM (random access memory) in the MGPS. Initial turn-on after manufacture, back-up battery failure, or usage after a significant constellation change are circumstances that would require collection of a new almanac via the satellite data message. This process takes 30 seconds for each satellite, or 12 minutes for 24 satellites. However, depending on the order of satellite almanacs in the data message, the almanacs for satellites currently above the horizon may be obtained before cycling through all existing satellites. Therefore, collection of almanac data to allow acquisition requires from 2 to 12 minutes.

Ephemeris

The satellite ephemeris provides an accurate estimate of satellite position at any given time. This data, like the almanac, is held in battery-backed RAM and is collected from the satellites on roughly an hourly basis during operation. Should the satellite track be interrupted for more than an hour (due to either signal blockage or the MGPS being turned off), the sensor will require the collection of new ephemeris before a solution will be made. Collection of this data requires 30 seconds per satellite or 2 minutes for 4 satellites (the number required for a 3-dimensional solution).

Initial Reference Position

At power-on, to estimate the proper frequencies and which satellites are visible, MGPS uses the almanac, time, and an estimate of current position. By default, the MPGS will use the last calculated position stored in memory. If the initial reference position is indeed a reasonable estimate of the true current position, the satellite dopplers will be accounted for correctly and acquisition will occur rapidly (a matter of seconds). However, if the search does not yield acquisition at the expected frequencies, the frequency search is expanded around the expected frequency for each satellite that is believed - by MGPS - to be above the horizon.

The MGPS does not require an initial position to acquire satellites and perform GPS solutions. A completely uninitialized set has the ability to determine its position autonomously. Under certain circumstances, the processor will execute a special acquisition algorithm. The "anywhere fix" is a process whereby the receiver uses the initial position stored in memory only as a starting place for doppler search calculations, but the position is not implicitly trusted. This process is invoked when sufficient time has passed since the last fix such that, based on expected velocity, the MGPS could have moved more then 150 km.

The anywhere fix process searches the expected satellite dopplers based on the initial position estimates. If the expected satellites are not found, the elevation mask is lowered to allow the receiver to search for other codes of satellites supposed below the mask. The anywhere fix mode will not have a significant impact on the time to first fix if indeed the initial position in memory is a reasonable estimate of true position. If the position is in extreme error, the search process could add up to 15 minutes to the time to first fix.

The following table summarizes "**Time-To-First-Fix (TTFF)" scenarios**:

MGPS state	Example Scenario	TTFF
Fully Initialized	Brief Power-Off	1.5 min*
Needs Ephemeris	Daily Power-On	3.5 min*
Needs Almanac	First Power-On after extreme constellation change	5 ... 15 min*
		* after "Warm up ended"

5

Signal Interruption

During MGPS operation, should the signal be interrupted (antenna blockage or disconnect, etc.), the re-acquisition time is dependent on events during the interruption. For the first minute of the interrupt, the MGPS continues to search for the last frequencies to which it was locked. If the signal is regained during this minute, reacquisition will be almost immediate if the user's velocity has not changed by more than 50 m/s. If velocity has changed, the doppler frequency has shifted. The MGPS must finish its one minute search of the previous frequencies then will expand the search to reacquire. The search time will depend on the amount of velocity change, but is usually within 15 seconds.

If the signal is regained after one minute has elapsed, the expanding frequency search will have already begun cycling. In this case reacquisition may require up to 4 or 5 minutes, depending on where the receiver is in the frequency search cycle when the signal is available.

If the signal is regained after one hour, the same search must take place, then ephemeris must be collected. In this case, re-aquisition will occur in less than 6 or 7 minutes. The user should realize that obstruction, shading and satellite transmission interruptions can degrade the signal reception and lengthen acquisition times.

Locked to GPS

Successful GPS satellite acquisition will result in the System reaching the "Locked to GPS" status.

Free Running

Generally, the MGPS will automatically revert to the "Free running" status when lock to GPS is not possible provided the MRK remains in "lock".
If the System is powered up and time data is not available from GPS, the time may be entered into the MGPS by using the edit option on the Main Menu as described in section 6.1 Main

Menu, page 21, Edit Mode. The System then will operate in the "Free running" mode.

Note that the software consists of averaging algorithms and that - when changing the location of the GPS antenna while operating the MGPS - the operating mode must be set to "Mobile" while moving and back to "Stationary" to start a new averaging process for the new position of the antenna site. Otherwise, it may occur that the MGPS reverts to the "Free running" status.

Rb Unlocked

In the event of fault conditions the MRK could turn to the "Rb unlocked" status. Then, the system will no longer generate valid time and frequency outputs.

6. DISPLAY MENUS

System status and data on Position, Time and Frequency are displayed on the Front Panel of the MGPS in a series of information menus that can be selected by operating the keypad as described below:

Keypad functions

⇧ ⇩	Used to toggle through the information menus and to increment or decrement digits or parameters in the Edit menus.
⇦ ⇨	Used to increment or decrement display brightness when in the information menus and to select digits or parameters when in the Edit menus.
C	Used to return to main menu with changes being cancelled.
E	Used to select an Edit menu and to return to main menu with changes made effective. Only available when enabled by key lock switch.

6.1. MAIN MENU

TIME:	TFOM:
DATE:	D:
MJD:	MODE:
STATUS:	

TIME:	HOURS:MINUTES:SECONDS	**TFOM:**	TIME FIGURE OF MERIT
DATE:	YEAR-MONTH-DAY	**D:**	DAY OF THE YEAR
MJD:	MODIFIED JULIAN DATE	**MODE:**	"Stat" or "Mob."
STATUS:	"Warm up" "Warm up ended" "Locked to GPS" "Free running" "Rb unlocked"		

The Time, Date, MJD and Day of the Year are synchronized to Coordinated Universal Time (UTC) as maintained by the United States Naval Observatory (USNO).

An explanation of the status of the MGPS is continued in the section 5. Operation.

The **Time Figure of Merit (TFOM)** denotes the quality of the time solution as a discrete integer from 1 to 9. The TFOM is based on Allan Variance measurements made by the MGPS of the time difference between the received GPS and MGPS system clocks and a 2nd order clock model assuming a MRK-L rubidium oscillator.

Integer	Estimated Accuracy with respect to UTC(USNO)
-	Unknown (not synchronized)
9	Greater than 10 ms or Rubidium unlocked
8	1 ms - 10 ms
7	100 µs - 1 ms
6	10 µs - 100 µs
5	1 µs - 10 µs
4	100 ns - 1 µs
3	10 ns - 100 ns
2	1 ns - 10 ns
1	Better than 1 ns

EDIT MODE

```
SET TIME MANUALLY:
yy-mm-dd      hh:mm:ss
```

Selected by pressing pushbutton "E" when in the Main Menu. Only available when the message "Warm up ended" is displayed on the Main Menu.

The cursor is moved by using the pushbuttons ⇦ and ⇨, the digit values are selected by using the pushbuttons ⇧ and ⇩. The new time data can be made effective by pressing pushbutton "E" resp. can be aborted by pressing pushbutton "C" to return to the MAIN MENU.

6.2. POSITION MENU

```
LAT:
LON:
ALT:          MODE:
SV#:
```

LAT: LATITUDE (degrees, minutes with 3 decimal digits, N / S)

LON: LONGITUDE (degrees, minutes with 3 decimal digits, E / W)

ALT: ALTITUDE (meters) **MODE:** Mode of GPS receiver operation

SV#: Space vehicle number(s) of satellites being tracked.

The displayed Latitude (LAT), Longitude (LON) and Altitude (ALT) indicates the position of the Antenna/ Preamplifier Unit with respect to the WGS84 (World Geodetic System 1984, see page 4) ellipsoid.

The Space Vehicle number (SV#) of each GPS satellite acquired is displayed. The number displayed refers to the pseudo random noise (PRN) code assigned to the SV.

In the Mobile mode (Mob.) the MGPS is actively updating the position of the Antenna/Preamplifier Unit provided satellites have been acquired.

In the Stationary mode (Stat) the position data reading is the result of averaging algorithms that are applied to all position data collected during continuous operation in the Stationary mode.

6.3. GPS RECEIVER STATUS

GPS RECEIVER STATUS: ACT. DELAY:

The following status codes are possible:

"Normal operation"	Displayed when the MGPS is controlled by GPS satellites in either the Stationary or Mobile mode.
"Waiting for almanac"	Indicating that the almanac data stored in the MGPS is not complete or current.
"Don't have GPS time"	Displayed during acquisition. Indicating that no time data have been received yet.
"No satellites usable"	The MGPS cannot acquire data from any GPS satellite. Indicating that either no satellites are above the horizon or that signal/ noise ratio is not sufficient (Antenna blocking, jamming etc.).
"Only 1 usable sat." **"Only 2 usable sat."**	Indicating that the number of satellites being tracked is less than that required to do position fixes.
"Only 3 usable sat."	("Mobile" mode only)
"PDOP is too high"	Indicating that the geometry of the satellites being tracked is such that the Position Dilution Of Precision (PDOP) is too high.
ACT. DELAY	Displaying the delay of the MGPS-generated 1PPS output as measured against the received GPS time, resp. UTC(USNO). Valid and updated only during normal operation.

ERROR MESSAGES

Error messages may replace status information and ACT. DELAY.
Refer to Maintenance section for more information if one or more of the following error messages occur:

"Battery back-up fail"	**"Alignment error ch.1"**
"Signal Proc. error"	**"Alignment error ch.2"**
"Antenna feed fault"	**"Osc. out of range"**
"Synthesizer fault"	**"Time clock fault"**
"A/D converter fault"	**"Unknown"**

6.4. AUXILIARY INPUT MENU

The status of the data received from an external timing source - connected to the 1PPS INPUT - is displayed in the AUXILIARY INPUT MENU.

CURRENT AUX. DELAY:
+/-######### ns

AUX. DELAY: Displays measured value of an applied pulse (leading edge) of an external timing source (see p. 28, 6.10. 1PPS Output Delay).

The leading edge of the MGPS 1PPS Output indicates the beginning of a UTC(MGPS) second. The displayed CURRENT AUX. DELAY corresponds to the timing pulse (leading edge) of the external timing source (1PPS INPUT) minus UTC(MGPS) plus the value for an **AUX-CALIBRATION** that has been **factory-set to compensate for delay times within the MGPS Module** and **should not be altered by the operator** (see also page 6, TIME SCALES, GPS and the MGPS MODULE).

The operator - if necessary - can program an AUX-CALIBRATION by first selecting the Edit menu with pressing pushbutton "E".

EDIT AUX-CALIBRATION:
+/-######### ns

The cursor is moved by using the pushbuttons ⇦ and ⇨, the digit values are selected by using the pushbuttons ⇧ and ⇩. The new data can be made effective by pressing pushbutton "E" respectively can be aborted by pressing pushbutton "C" to return to the Main Menu.

To execute a reasonable AUX-CALIBRATION the operator should proceed as follows:

1. Case that the AUX-CALIBRATION displayed is not 0 ns, program an AUX-CALIBRATION of 0 ns.

2. Use a cable with a known cable delay time to perform a short-circuit by connecting the 1PPS Output with the 1PPS Input of the MGPS Module.

3. Read displayed value for CURRENT AUX. DELAY. Note that a cable delay time, e.g. +10 ns, should lead to a CURRENT AUX. DELAY of -10 ns. If the displayed value differs from the known cable delay time, the correct AUX-CALIBRATION to be programed can be calculated as:

   AUX-CAL. = - (known **CABLE DELAY TIME**) **-** (displayed value of **CURRENT AUX. DELAY**)

6.5. UPDATE INFORMATION MENU

The last Time and Frequency corrections under the control of the GPS are displayed. The time elapsed since the last update is indicated by the "AGE" reading.

TIME CORR:	
BY:	AGE:
FREQ CORR:	
BY:	AGE:

TIME CORR: The last time correction applied to the MGPS 1PPS. "No update" is displayed when waiting for first correction.

BY: Displays "GPS" when under GPS control.

AGE: Time elapsed since last correction expressed in hours: minutes: seconds

FREQ CORR: The last frequency correction applied to the MGPS control voltage output to steer the MRK. "No update" is displayed when waiting for first correction.

6.6. CONTROL VOLTAGE

CONTROL VOLTAGE:

CONTROL VOLTAGE: Expressed in Volt (0 - 5V) and percentage of full range (0 - 100%).

The dc control voltage output of the MGPS is connected to the C-field input of the MRK Rubidium Oscillator.

The C-field input controls the frequency of the MRK and is adjusted to counteract the effects of Rubidium Oscillator drift and frequency changes due to temperature.

Offsets in frequency due to Rubidium Oscillator drift etc. are computed in the MGPS with reference to the GPS System. The appropriate frequency correction is made to the MRK C-field by adjusting the control voltage.

The Maintenance section of the MRK Rubidium Oscillator Manual should be consulted when the control voltage is approaching out of range limits.

6.7. CURRENT LEAP SECOND

CURRENT LEAP SECOND:
yy-mm-dd hh:mm:ss

The display indicates the date and time of the current leap second.
Leap second data are hourly updated by GPS satellite transmission (automatically).

A leap second can also be programed by the operator. To program a leap second date and time, it is first necessary to select the Edit Menu by pressing pushbutton "E".

EDIT LEAP SECOND:
yy-mm-dd hh:mm:ss

The cursor is moved and digit values selected using the pushbuttons as described for the Edit mode in the Main Menu.

6.8. RECEIVER MODE MENU

CURRENT RECEIVER MODE:
SV#:

CURRENT RCVR MODE: Displays either "Stationary" or "Mobile"

SV#: Space vehicle number(s) of satellites being tracked.

The receiver mode can be changed by first pressing pushbutton "E" to enter the EDIT RECEIVER MODE menu.

EDIT RECEIVER MODE:
Stationary

Pressing pushbuttons ⇧ and ⇩ will select the "Stationary" or the "Mobile" mode.
Press pushbutton "E" to enter, respectively "C" to abort.

6.9. UPDATING RATE MENU

```
CURRENT TIME CORR.
EVERY
CURRENT FREQ CORR.
EVERY
```

CURRENT TIME CORR. EVERY: Displays the time interval used to average GPS receiver data for time corrections.

CURRENT FREQ. CORR. EVERY: Displays the time interval used to average GPS receiver data for frequency corrections.

The rate at which time corrections from GPS are applied to update the MGPS is under operator control.

Time corrections will be applied to the 1PPS output, independent of the rubidium oscillator frequency and not affecting it.

Similarly, the rate at which frequency corrections from GPS are applied to calibrate the MRK rubidium oscillator is also under operator control.

The factory-set Time Correction **Every 4 Hours** and Frequency Correction **Every 24 Hours** are recommended settings applicable to laboratory environments. Consult factory for different applications and settings.

Updating rates can be changed by pressing pushbutton "E" to enter Edit mode.

```
EDIT TIME CORR:
EVERY
EDIT FREQ CORR:
EVERY
```

Pressing pushbuttons ⇧ and ⇩ will move the cursor to the EDIT TIME CORR. or EDIT FREQ CORR. field. Pressing pushbuttons ⇦ and ⇨ will decrease or increase the time interval.
Press pushbutton "E" to enter or "C" to abort.

6.10. 1PPS OUTPUT DELAY

```
CURRENT USER DELAY:
+/-######### ns
```

CURRENT USER DELAY: Displays the CURRENT USER DELAY in nanoseconds programmed by the operator.

+ indicates: 1PPS output is advanced
UTC(MGPS) ≥ UTC(USNO)

- indicates: 1PPS output is retarded
UTC(MGPS) < UTC(USNO)

(See also page 6, TIME SCALES, GPS and the MGPS MODULE)

To change the delay of the 1PPS output press pushbutton "E" to enter the Edit mode.

```
EDIT USER DELAY:
+/-######### ns
```

The cursor is moved by using the pushbuttons ⇦ and ⇨, the digit values are selected by using the pushbuttons ⇧ and ⇩. The new data can be made effective by pressing pushbutton "E" respectively can be aborted by pressing pushbutton "C" to return to the Main Menu.

ATTENTION:
The insertion of a USER DELAY will shift the 1PPS output !

The user delay is used to calibrate the MGPS for an accurate 1PPS output. It is factory-set to compensate for the length of the antenna cable supplied with the MGPS.

6.11. RS-232 Interface Menu

```
BAUDRATE: ____9600___
STOPBITS:  ____2______
CHAR-LEN: ____8______
PARITY:  ______off
```

To establish communication between the MGPS and an IBM compatible personal computer using the RS-232 interface, the following parameter settings have to be selected as shown above.

Baudrate:	9600	(Baud)
Stopbits:	2	(2 stop bits)
Char-Len:	8	(8 bit word length)
Parity:	off	(no parity bit)

Press pushbutton " **E** " to enter the Edit menu. Note that the key lock switch must be turned to position "unlocked".

Press ⇧ or ⇩ to move the cursor from line to line.

Press ⇦ or ⇨ to change the parameter settings.

The new settings can be made effective by pressing pushbutton "E" respectively can be aborted by pressing pushbutton "C" to return to the MAIN MENU.

The software utility to be used is provided by a floppy disk and is enclosed with the MGPS package.

Files on the diskette:

README.TXT (ASCII format)

COMM.BAT

MGPS \ MGPSCOM.BAS

MGPS \ PROG \ MGPSCOM.EXE

The table on the following page shows the function keys to use, the according commands, the title and kind of data and an example for each possible data output.

TABLE

RS-232 DATA OUTPUT

KEY	COMMAND	DATA	OUTPUT EXAMPLE
F1	STS?	STATUS	Status as of 93-05-14 06:10:59.328 Mod. Jul. Date 49121.257 Power low at 00-01-01 00:00:00.000 MRK unlock at 00-01-01 00:00:00.000 MRK locked at 00-01-01 00:06:00.016 System state : Locked to GPS Operating mode : Stationary Control voltage: 2.2632 V Softwareversion: MGPS0174 93-05-13 EOF
F2	HIS?	HISTORY	93-05-14 06:10:48 Time corr. by GPS -4.59ns -6.32ns 93-05-14 05:10:48 Time corr. by GPS. +0.00ns -6.00ns 93-05-14 04:10:48 Freq corr. by GPS: +5.997E-12 93-05-14 04:10:48 Time corr. by GPS +27.56ns -5.67ns 93-05-14 03:10:48 Time corr. by GPS. +13.78ns -5.34ns 93-05-14 02:10:48 Time corr. by GPS: +18.37ns +0.20ns 93-05-14 01:10:48 Time corr. by GPS. +22.97ns +0.48ns 93-05-14 00:10:48 Time corr. by GPS. +22.97ns +0.75ns 93-05-13 23:10:48 Time corr. by GPS. -165.39ns +1.02ns 93-05-13 22:10:48 Freq corr. by GPS: -1.243E-10 93-05-13 22:10:48 Time corr. by GPS. -519.15ns +1.30ns 93-05-13 21:10:48 Time corr. by GPS: -450.24ns +1.57ns 93-05-13 20:10:48 Time corr. by GPS: -482.40ns +1.85ns 93-05-13 19:10:48 Time corr. by GPS: -431.86ns +2.13ns 93-05-13 18:10:48 Time corr. by GPS. -358.35ns +2.40ns 93-05-13 17:10:48 Time corr. by GPS: -505.37ns +2.68ns 93-05-13 15:10:26 Time transferred by GPS 00-01-01 00:09:04 Sync. by GPS EOF
F3	POS?	POSITION	47 59.193'N 11 42.450'E + 677m EOF
F4	ATM?	TIME	93-05-14 06:11:06.871 EOF
F5	DOY?	DAY OF YEAR	134 EOF
F6	MJD?	MJD	49121.257 EOF
F7	SAT?	SIGNAL	Satellite: 17 Signal level: +00000005 Satellite: 19 Signal level: +00000005 Satellite: 16 Signal level: +00000021 Satellite: 27 Signal level: +00000018 EOF
F8	AUX?	AUX ON	93-05-13 16:26:05.000000364 93-05-13 16:26:06.000000365 93-05-13 16:26:07.000000365 93-05-13 16:26:08.000000365 93-05-13 16:26:09.000000365 93-05-13 16:26:10.000000365 93-05-13 16:26:11.000000365 93-05-13 16:26:37.000000370 93-05-13 16:26:38.000000369 93-05-13 16:26:39.000000369 93-05-13 16:26:40.000000369 93-05-13 16:26:41.000000369 93-05-13 16:26:42.000000370 93-05-13 16:26:43.000000369 93-05-13 16:27:09.000000373 93-05-13 16:27:10.000000374 93-05-13 16:27:11.000000374 93-05-13 16:27:12.000000374 93-05-13 16:27:13.000000374 93-05-13 16:27:14.000000374 93-05-13 16:27:15.000000374 93-05-13 16:27:41.000000378 93-05-13 16:27:42.000000378 93-05-13 16:27:43.000000378 93-05-13 16:27:44.000000379 93-05-13 16:27:45.000000379 EOF
F9	NOX?	AUX OFF	EOF
ESC		END	

7. MAINTENANCE

Routine maintenance is not required.

TROUBLESHOOTING / ERROR MESSAGES

The tables on the following pages shall give information on different error messages and possible actions for troubleshooting.

Initialization to factory-set default values (Curr. Time Corr. and Curr. Freq. Corr., Control Voltage 2.5V) is executed by a **cold start** (do only perform when necessary !).

A simple **reset** is performed by a **warm start**, without affecting default values (see above) that have been changed by the operator.

NOTE:

Performing a "**warm start**" requires **simultaneously pressing** the keys: ⇧ + ⇦ + **E**

A "**cold start**" is performed by **simultaneously pressing and holding** 1. ⇧ + ⇦ + **E**

HOLD +

and additional pressing: 2. ⇨

ERROR MESSAGE	TYPE OF ERROR	ACTION
Error No. Error Address ⇩ ⇩ Error # 00 @ $ ---- ... # 62 @ $ ----	Fatal Error	1. Note down Error No. and Address. 2. Try to execute a warm start. 3. If warm start fails, try cold start. 4. In any case: contact factory.
Battery back-up fail **Signal Proc. error** **Alignment error ch.1** **Alignment error ch.2** **Osc. out of range** **Synthesizer fault** **A/D converter fault** **Unknown**	Fatal Error (GPS Receiver Status Menu)	1. Try warm start. 2. If warm start is not successful, contact factory.
Time clock fault	Fatal Error (GPS Receiver Status Menu)	1. Let the unit operate for at least one hour. 2. Try warm start. 3. If warm start is not successful, contact factory.
Antenna feed fault	Status information (GPS Receiver Status Menu)	1. Check co-axial cable (connection of Antenna/Preamplifier Unit with MGPS input) for continuity and shorts. 2. If this connection is sound, the Antenna/Preamplifier should be replaced. **NOTE:** When source of error is eliminated, the error message will be cleared automatically.

ERROR MESSAGE	TYPE OF ERROR	ACTION
Don't have GPS time	Status information (GPS Receiver Status Menu)	Error message which is displayed during acquisition, indicating that no time data has been received yet. **NOTE:** The message will be cleared automatically. It may take several hours - dependent on env. conditions - to change status; if there is still no change of Receiver status after 24 hours, contact factory.
PDOP is too high (Position Dilution Of Precision)	Status information (GPS Receiver Status Menu)	Indicating that the geometry of the satellites being tracked is such that the Position Dilution Of Precision (PDOP) is too high. **NOTE:** The message will be cleared automatically. It may take several hours - dependent on env. conditions - to change status; if there is still no change of Receiver status after 24 hours, contact factory.
No satellites usable	Status information (GPS Receiver Status Menu)	The MGPS cannot acquire data from any GPS satellite. Indicating that either no satellites are above the horizon or that signal/noise ratio is not sufficient (Antenna blocking, jamming, etc.). **NOTE:** The message will be cleared automatically. It may take several hours - dependent on env. conditions - to change status; if there is still no change of Receiver status after 24 hours, contact factory.
Only 1 usable sat **Only 2 usable sat** **Only 3 usable sat** *) *) MOBILE mode only	Status information (GPS Receiver Status Menu)	Indicating that the number of satellites being tracked is less than that required to do position fixes. **NOTE:** The message will be cleared automatically. It may take several hours - dependent on env. conditions - to change status; if there is still no change of Receiver status after 24 hours, contact factory.

7

ERROR MESSAGE	TYPE OF ERROR	ACTION
Waiting for almanac	Status information (GPS Receiver Status Menu)	Indicating that the stored almanac data is not complete and/or current. **NOTE:** The message will be cleared automatically. It may take several hours - dependent on env. conditions - to change status; if there is still no change of Receiver status after 24 hours, contact factory.
Free Running	Status information (GPS Main Menu)	Generally, the MGPS will automatically revert to the "Free running" status when lock to GPS is not possible provided the MRK remains in "lock". If the System is powered up and time data is not available from GPS, the time may be entered into the MGPS by using the edit option on the Main Menu as described in section 6.1 Main Menu, page 20, EDIT MODE. The System then will operate in the "Free running" mode. **NOTE:** The software consists of averaging algorithms and - when changing the location of the GPS antenna while operating the MGPS - the operating mode must be set to "Mobile" while moving and back to "Stationary" to start a new averaging process for the new position of the antenna site. Otherwise, it may occur that the MGPS reverts to the "Free running" status.

APPENDIX A

GUIDELINES FOR DETERMINING THE REQUIRED MGPS ANTENNA CABLE LENGTH

1.0 CALIBRATION METHOD

Unless otherwise specified, the MGPS cable length is determined (and calibrated into the MGPS software) at the factory and a cable of suitable length is provided with the MFS/ MGPS system. If the cable is later cut by the user, or the user is providing the cable for the site, the MGPS calibration ("USER DELAY") must be edited at the front panel keypad of the MGPS (refer to the MGPS User Manual for instructions). The antenna cable insertion loss must not exceed the specification (refer to the specifications section of the MGPS User Manual).

Coaxial cables provide a well defined propagation delay that depends primarily on the dielectric constant of the insulation material. As of Jan. 1993 Ball Efratom Division began offering 25m of RG213/U as a standard antenna cable, or optionally 70m of AIRFLEX low loss cable, both of which meet the 10dB insertion loss requirement without an additional preamplifier.

Cable Type	Delay per Meter	Nominal Length	Total Delay
RG213/U	5.05ns/m	25m	126.25ns
AIRFLEX	3.92ns/m	70m	274.40ns

since

$$UTC(MGPS) = UTC(USNO) - T_C - T_R + USER\ DELAY \quad (1)$$

with

T_C	cable delay
T_R	receiver delay
UTC(MGPS)	MGPS time scale as represented by 1 pps output
UTC(USNO)	USNO time scale as transferred to MGPS at antenna location

For

$$UTC(MGPS) = UTC(USNO) \quad (2)$$

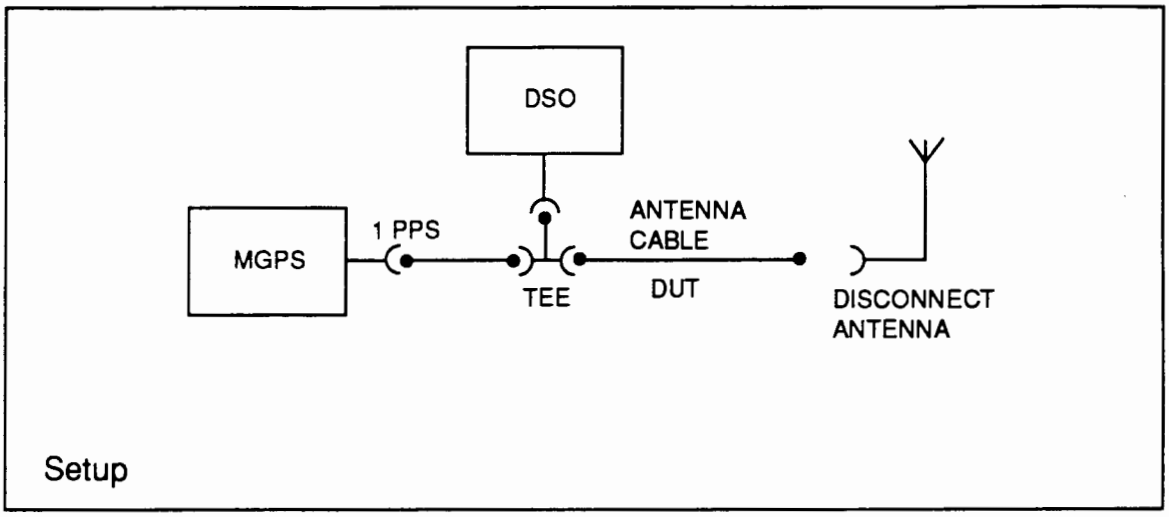
Follows

$$USER\ DELAY = T_C + T_R \quad (3)$$

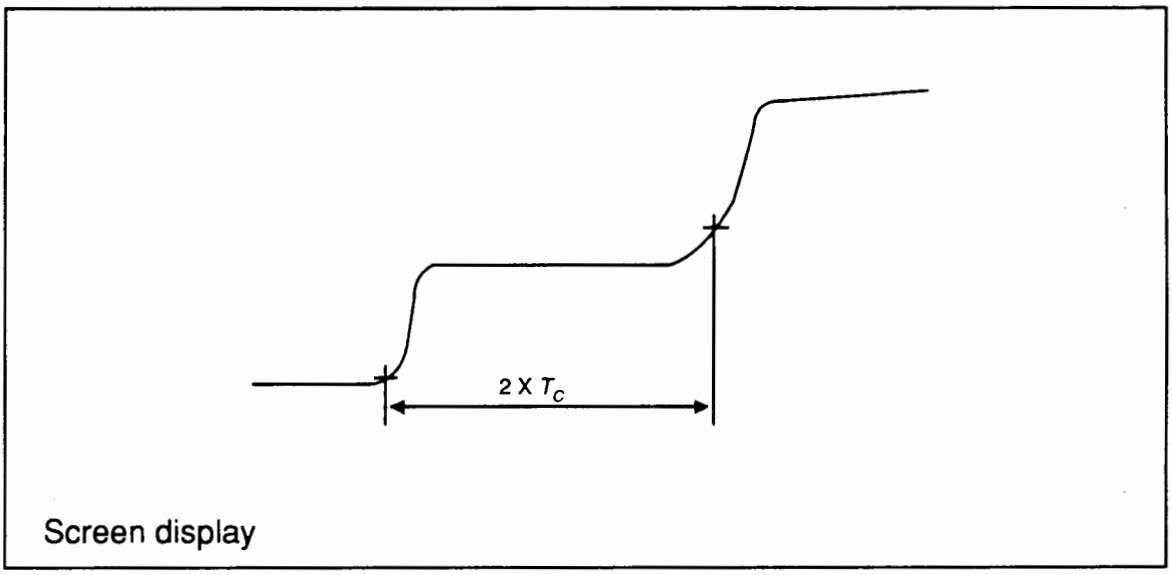
Cutting the cable supplied by a known length reduces the MGPS 1pps delay. To maintain the relationship of equation (2) the USER DELAY must be reduced accordingly.

Example: cutting 3.5 meters off a RG213/U cable reduces the cable delay by 3.5m *5.05ns/m = 17.675ns. The USER DELAY must therefore be reduced by the same (rounded) value of 18ns.

If a user supplied cable is used, the cable propagation can be determined using pulse reflectometry.



Setup



Screen display

Determine T_C as shown above and set USER DELAY per equation (3).

APPENDIX B

USING AN IBM COMPATIBLE PC AS A DATA LOGGER FOR THE MGPS

1.0 REQUIREMENT

1.1 IBM compatible, 12 MHz minimum, 286, 4 megabytes RAM with COM1 and COM2 open.

1.2 Windows Version 3.1 with Terminal and Write utilities.

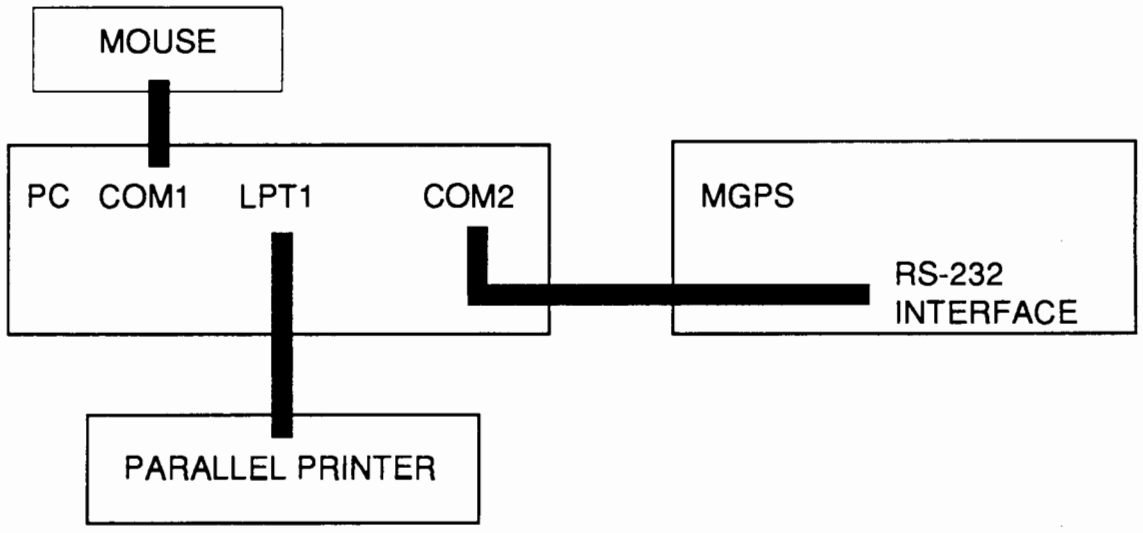
1.3 RS-232 cable.
The cable is connected between the MGPS and the PC as shown below:

MGPS		PC
9 pin D-sub, male		25 pin D sub, female
2	----------	3
3	----------	2
4	----------	5
5	----------	20
7	----------	7

1.4 Serial mouse and driver software.

2.0 PROCEDURE

2.1 Connect the cable from the RS-232 interface of the MGPS front panel to the COM2 of the PC. The mouse can be connected to COM1. If desired, connect a parallel printer to LPT1 of the PC. Turn the power of the IBM PC on.



2.2 Type "CD WINDOWS" and then "WIN" at the DOS prompt. This will put the system into Windows mode.

2.3 Select the Terminal application by highlighting the icon and clicking the left button of the mouse twice.

2.4 Select **Settings** and go to **Communication**. Set these parameters as shown below:

Connector	Com2
Baud Rate	9600
Parity	none
Data Bits	8 bits
Stop Bit	1 bit
Parity Check	Not Selected
Carrier Detect	Not Selected
Flow Control	Xon/Xoff

2.5 The MGPS outputs data to the PC everytime it makes an update. With the current software version there is no data input to the MGPS, however the next software version will allow the MGPS to communicate and make data available on request.

2.6 Select Save from the **File** menu to name the Set-up file and save it.

2.7 There are two methods of printing out the data file:

1. From the **Settings** menu select Printer Echo. This will print screens as long as there is data coming from the MGPS.

2. Pull down the **Edit** menu and use the copy and paste functions to place the data into the Windows utility called Write. The data file can be both saved and printed from this utility.

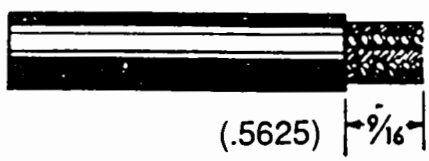
   NOTE: The printer must be setup properly. Use Printer Setup under the **File** menu, or Print Manager (available by clicking on its icon). Refer to the Microsoft Windows user manual for more information of printer setup.

APPENDIX C

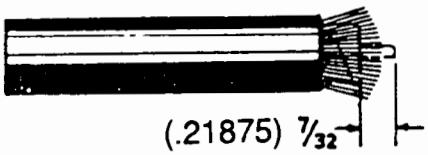
PREPARING COAX CABLE TERMINATIONS

TYPE N CONNECTORS

Standard Clamp

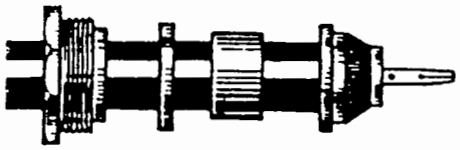


1) Cut cable and even. Remove 9/16″ of vinyl jacket. When using double-shielded cable remove 5/8″.

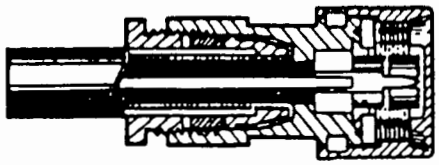


2) Comb out copper braid as shown. Cut off dielectric 7/32″ from end. Tin center conductor.

3) Taper braid as shown. Slide nut, washer and gasket over vinyl jacket. Slide clamp over braid with internal shoulder of clamp flush against end of vinyl jacket. When assembling connectors with gland, be sure knife-edge is toward end of cable and groove in gasket is toward the gland.



4) Smooth braid back over clamp and trim. Soft-solder contact to center conductor. Avoid use of excessive heat and solder. See that end of dielectric is clean. Contact must be flush against dielectric. Outside of contact must be free of solder. Female contact is shown; procedure is similar for male contact.



5) Slide body into place carefully so that contact enters hole in insulator (male contact shown). Face of dielectric must be flush against insulator. Slide completed assembly into body by pushing nut. When nut is in place, tighten with wrenches. In connectors with gland, knife edge should cut gasket in half by tightening sufficiently.

APPENDIX D

IRIG Code Option for MGPS Receiver / Controller Systems

1. Description

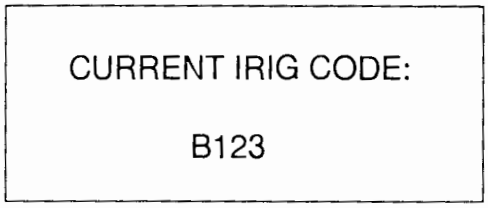
The optional IRIG Code Generator provides a time code output for the MGPS Receiver / Controller System. It generates under software control from the MGPS processor, standard instrumentation time codes as defined in IRIG (Inter-Range Instrumentation Group) document No. 104-70. Codes designated "A", "B", "G", or "E" can be selected from the MGPS front panel. The BNC type output connector for the time code option is located at the MGPS rear panel connector "TC OUTPUT" (TC = TIME CODE).

2. Specification

Rate Designation:	A	1000 pps
	B	100 pps
	E	10 pps
	G	10000 pps
Form Designation:	1	Sine wave amplitude modulated
Carrier Frequency / Resolution:	1	100 Hz / 10 ms
	2	1 kHz / 1 ms
	3	10 kHz / 0.1 ms
	4	100 kHz / 0.01 ms
Coded Expressions:	2	BCD
	3	BCD, SBS
Default Setting (factory):	B 1 2 3	
Selectable Settings:	A133	
	B123	
	E112	
	E122	
	G142	

3. How to Change Settings

3.1 Select MGPS display menu for IRIG Code.



3.2 Press "E" to enable editing for IRIG Code setting.

3.3 Use keys ↑ and ↓ to change setting.

3.4 Press either "C" to cancel all changes, or press "E" to save new setting.

Index

K

L

M

N

O

P

Q

R

S

T

U

W