MEINBERG
FUNKUHREN

Technical Information

Operating Instructions

GPS163DHS

GPS163AHS

Incl. Windows Software
GPSMON32

Impressum

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General information

The satellite receiver clocks GPS163DHS and GPS163AHS have been designed to provide an extremly precise time reference for the generation of programmable pulses. The variants are different in the power supply (DC or AC) only. The name GPS163xHS is used for both clocks in the following chapters therefore. The differences are described in the relevant chapters.

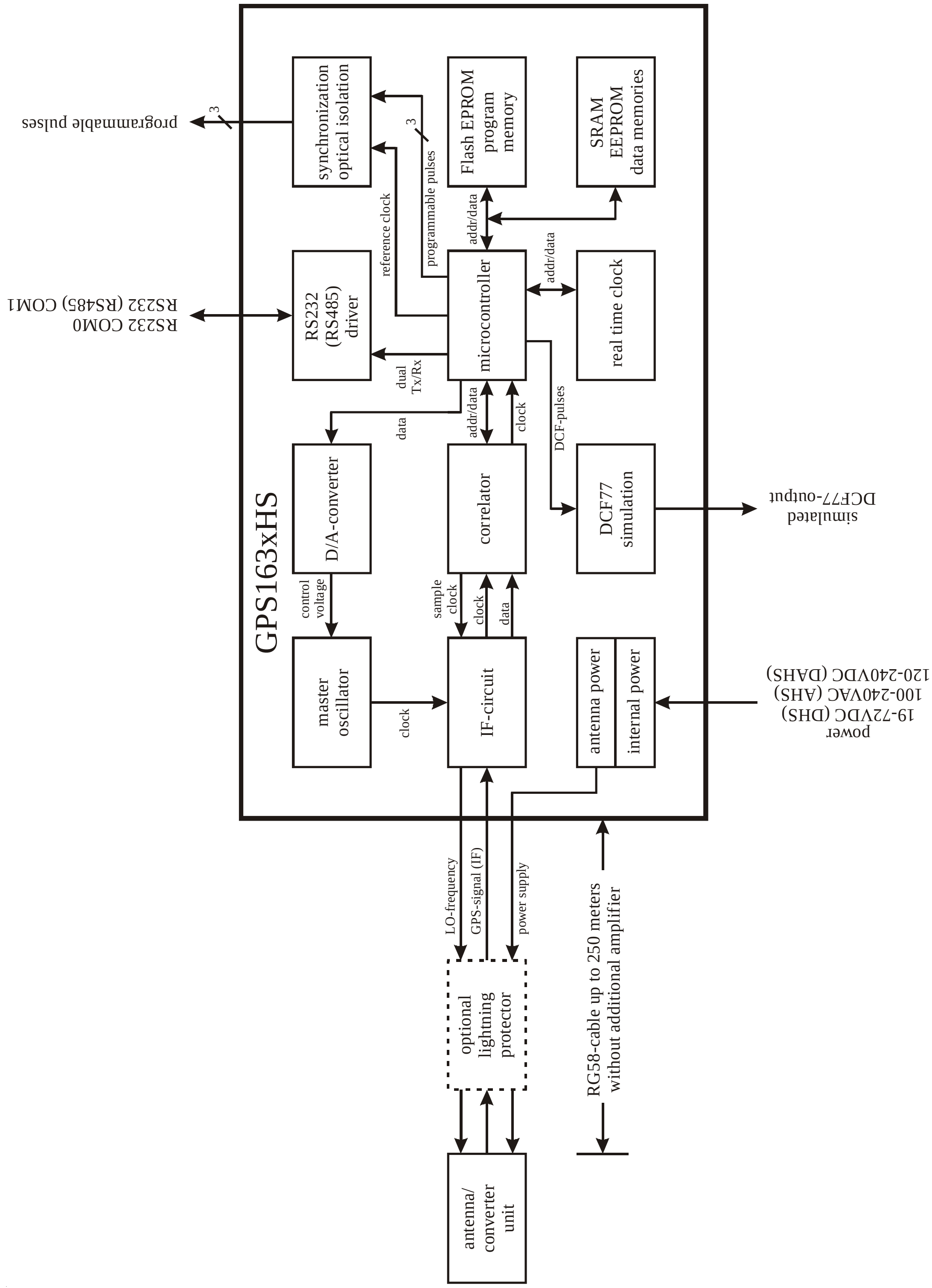
The clocks have been developed for applications where conventional radio controlled clocks can´t meet the growing requirements in precision. High precision available 24 hours a day around the whole world is the main feature of the new systems which receive their information from the satellites of the Global Positioning System.

The Global Positioning System (GPS) is a satellite-based radio-positioning, navigation, and time-transfer system. It was installed by the United States Departement of Defense and provides two levels of accuracy: The Standard Positioning Service (SPS) and the Precise Positioning Service (PPS). While PPS is encrypted and only available for authorized (military) users, SPS has been made available to the general public.

GPS is based on accurately measuring the propagation time of signals transmitted from satellites to the user´s receiver. A nominal constellation of 21 satellites together with 3 active spares in six orbital planes 20000 km over ground provides a minimum of four satellites to be in view 24 hours a day at every point of the globe. Four satellites need to be received simultaneously if both receiver position (x, y, z) and receiver clock offset from GPS system time must be computed. All the satellites are monitored by control stations which determine the exact orbit parameters as well as the clock offset of the satellites´ on-board atomic clocks. These parameters are uploaded to the satellites and become part of a navigation message which is retransmitted by the satellites in order to pass that information to the user´s receiver.

The high precision orbit parameters of a satellite are called ephemeris parameters whereas a reduced precision subset of the ephemeris parameters is called a satellite´s almanac. While ephemeris parameters must be evaluated to compute the receiver´s position and clock offset, almanac parameters are used to check which satellites are in view from a given receiver position at a given time. Each satellite transmits its own set of ephemeris parameters and almanac parameters of all existing satellites.

Block diagram GPS163xHS



GPS163xHS features

The GPS163xHS is designed for mounting on a DIN rail. The front panel integrates five LED indicators, a hidden push button, an eight-pole terminal block, two DSUB- and two BNC-connectors. The receiver is connected to the antenna/converter unit by a 50 Ω-coaxial cable with length up to 250 m. It is possible to connect up to four receivers to one antenna by using an optional antenna diplexer.

The navigation message coming from the satellites is decoded by GPS163xHS´s microprocessor in order to track the GPS system time with an accuracy of better than ±1 µsec. Compensation of the RF signal´s propagation delay is done by automatical determination of the receiver´s position on the globe. A correction value computed from the satellites´ navigation messages increases the accuracy of the board´s TCXO to $\pm 5 \cdot 10^{-9}$ and automatically compensates the oscillators aging. The last recent value is restored from the battery buffered memory at power-up.

Time zone and daylight saving

GPS system time differs from the universal time scale (UTC) by the number of leap seconds which have been inserted into the UTC time scale after GPS has been initiated in 1980. The current number of leap seconds is part of the navigation message supplied by the satellites, so GPS163xHS´s internal real time is based on UTC.

Conversion to local time including handling of daylight saving year by year can be done by the receiver´s microprocessor if the corresponding parameters are set up with the help of the software GPSMON32 (included Windows software).

Pulse outputs

The pulse generator of the satellite controlled clock GPS163xHS containes three independant channels and is able to generate a multitude of different pulses, which are configured with the software GPSMON32.

The active state of each channel is invertible, the pulse duration settable between 10 msec and 10 sec in steps of 10 msec.

In the default mode of operation the pulse outputs are disabled until the receiver has synchronized after power-up. However, the system can be configured to enable those outputs immediately after power-up.

The pulse outputs are electrically insulated by optocouplers (option: PhotoMOS relays) and are available at the terminal block.

The following modes can be configured for each channel independently:

Timer mode:	Three on- and off-times per day per channel programmable
Cyclic mode:	Generation of periodically repeated pulses. A cycle time of two seconds would generate a pulse at 0:00:00, 0:00:02, 0:00:04 etc.
DCF77-Simulation mode:	The corresponding output simulates the DCF77 time telegram. The time marks are representing the local time as configured by the user.
Single Shot Mode:	A single pulse of programmable length is generated once a day at a programmable point of time
Per Sec. Per Min. Per Hr. modes:	Pulses each second, minute or hour
Status:	One of three status messages can be emitted: 'position OK': The output is switched on if the receiver was able to compute its position 'time sync': The output is switched on if the internal timing is synchronous to the GPS-system 'all sync': Logical AND of the above status messages. The output is active if position is calculated AND the timing is synchronized
Idle-mode:	The output is inactive

Asynchronous serial ports

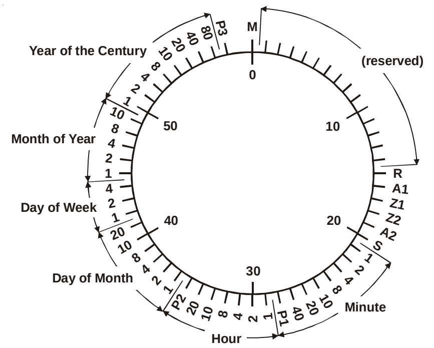
Two asynchronous serial interfaces (RS-232) called COM0 and COM1 are available to the user. In the default mode of operation, the serial outputs are disabled until the receiver has synchronized after power-up. However, the system can be configured to enable those outputs immediately after power-up. Transmission speeds, framings and the kind of the time string can be configured separately. The serial ports are sending a time string either once per second, once per minute or on request with ASCII ´?´ only. The format of the output strings is ASCII, see the technical specifications for details. The corresponding parameters can be set up by GPSMON32 (included Windows software) using serial port COM0.

Optionally serial port COM1 can be delivered as an RS-485 interface.

DCF77 emulation

The GPS163xHS satellite controlled clock generates time marks which are compatible with the time marks spread by the German long wave transmitter DCF77. If configured in GPSMON32, these time marks are available as pulse outputs. In addition, an AM-modulated carrier frequency of 77.5kHz is available via a BNC-connector in the front panel. This signal can be used as a replacement for a DCF77-antenna.

The long wave transmitter installed in Mainflingen near Frankfurt/Germany transmits the reference time of the Federal Republic of Germany: time of day, date of month and day of week in BCD coded second pulses. Once every minute the complete time information is transmitted. However, GPS163xHS generates time marks representing its local time as configured by the user, including announcement of changes in daylight saving and announcement of leap seconds. The coding sheme is given below:



M	Start of Minute (0.1 s)	
R	RF Transmission via secondary antenna	
A1	Announcement of a change in daylight saving	
Z1, Z2	Time zone identification	
	Z1, Z2 = 0, 1:	Daylight saving disabled
	Z1, Z2 = 1, 0:	Daylight saving enabled
A2	Announcement of a leap second	
S	Start of time code information	
P1, P2, P3	Even parity bits	

Time marks start at the beginning of new second. If a binary "0" is to be transmitted, the length of the corresponding time mark is 100 msec, if a binary "1" is transmitted, the time mark has a length of 200 msec. The information on the current date and time as well as some parity and status bits can be decoded from the time marks of the 15th up to the 58th second every minute. The absence of any time mark at the 59th second of a minute signals that a new minute will begin with the next time mark.

Installation

Power supply

The variant GPS163DHS is designed for operation with a DC (19 V to 72 V, DC-insulation 1.5 kV), the type GPS163AHS with an AC (100V to 240V, 47 Hz to 63 Hz) power supply. The voltage feed is done through terminal blocks in the frontpanel of the clock and should have low resistance to minimize spurious emission (EMI). GPS163AHS includes a fuse which is available at the front panel.

To avoid potential differences between the signal ground of GPS163xHS and a post-connected unit installed on different DIN rails, the signal ground of the clock is insulated from the case.

The case must be grounded by using the rear contact.

Mounting the antenna

The GPS satellites are not stationary but circle round the globe in a period of about 12 hours. They can only be received if no building is in the line-of-sight from the antenna to the satellite, so the antenna/converter unit must be installed in a location from which as much of the sky as possible can be seen. The best reception is given when the antenna has a free view of 8° angular elevation above horizon. If this is not possible the antenna should be installed with a mostly free view to the equator because of the satellite courses which are located between latitudes of 55° North and 55° South. If even this is not possible problems occure especially when at least four sattelites for positioning have to be found.

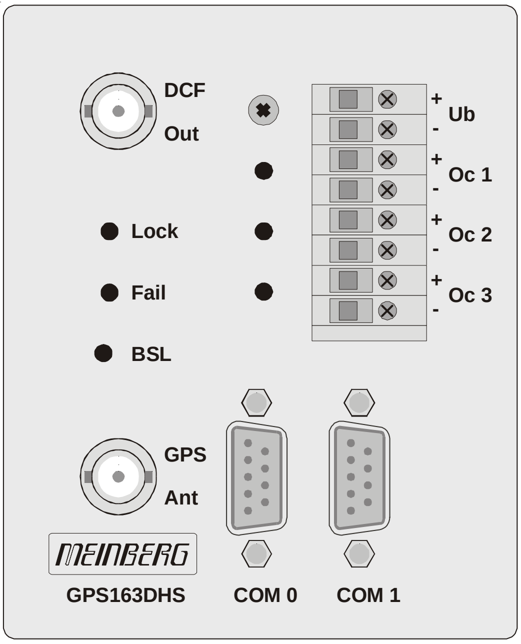
The unit can be mounted using a pole with a diameter up to 60 mm. A standard coaxial cable with 50 Ω impedance (e.g. RG58C) should be used to connect the antenna/converter unit to the receiver. Cable thinner than RG58 should be avoided due to its higher DC resistance and RF attenuation. When using the optional antenna diplexer the total length of one antenna line between antenna, diplexer and receiver must not be longer than 250 m. If a cable with less attenuation is used its length may be increased accordingly (e.g. 500 m with RG213).

Powering up the system

If both, the antenna and the power supply have been connected, the system is ready to operate. About 10 seconds after power-up the receiver´s TCXO has warmed up and operates with the required accuracy. If the receiver finds valid almanac and ephemeris data in its battery buffered memory and the receiver´s position has not changed significantly since its last operation the receiver can find out which satellites are in view now. Only a single satellite needs to be received to synchronize and generate output pulses, so synchronization can be achieved maximally one minute after power-up.

If the receiver position has changed by some hundred kilometers since last operation, the satellites´ real elevation and doppler might not match those values expected by the receiver thus forcing the receiver to start scanning for satellites. This mode is called **Warm Boot** because the receiver can obtain ID numbers of existing satellites from the valid almanac. When the receiver has found four satellites in view it can update its new position and switch to **Normal Operation**. If the almanac has been lost because the battery had been disconnected the receiver has to scan for a satellite and read in the current almanacs. This mode is called **Cold Boot**. It takes 12 minutes until the new almanac is complete and the system switches to Warm Boot mode scanning for other satellites.

The front panel layout



FAIL LED

The FAIL LED is turned on whenever the receiver is not synchronous to the GPS-system.

LOCK LED

The LOCK LED is turned on if the receiver has acquired at least four satellites and has computed its position after power-up. In normal operation the receiver position is updated continuously as long as at least four satellites can be received. When the receivers position is known and steady only, a single satellite needs to be received for synchronization and generatation of output pulses.

OCx LEDs

The LEDs OC1, OC2 and OC3 are indicating the status of the corresponding pulse output. A burning LED symbolizes the ON-state of an optocoupler.

BSL Key

Whenever the on-board software must be upgraded or modified, the new firmware can be downloaded to the internal flash memory using the serial port COM0. There is no need to open the metal case and insert a new EPROM.

If the BSL key behind the front panel is pressed during operation, a bootstrap-loader is actived and waits for instructions from the serial port COM0. The new firmware can be sent to GPS163xHS from any standard PC with serial interface. A loader program will be shipped together with the file containing the image of the new firmware.

The contents of the program memory will not be modified until the loader program has sent the command to erase the flash memory. So, if the BSL key is pressed unintentionally, the firmware will not be changed accidentially. After the next power-up, the system will be ready to operate again.

BNC connector DCF Out

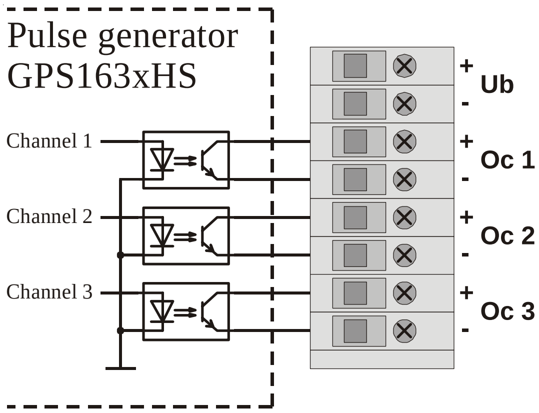
The insulated AM-modulated carrier frequency is available using this connector.

BNC connector GPS Ant

The antenna/converter unit is connected to the receiver circuit of the GPS163xHS through this connector.

Assignment of the terminal block

The pulse outputs are accessible through the terminal block in the front panel. In addition, the power supply is connected to GPS163DHS via two poles of this terminal block. The marking besides the terminal has the following meaning:



+ Ub	positive potential of power supply
- Ub	reference potential of power supply
+ OCx	Collector of photocoupler
- OCx	Emitter of photocoupler

Assignment of the DSUB connectors

The serial ports COM0 and COM1 are accessible via nine-pole DSUB connectors in the frontpanel. These RS-232 interfaces can be connected to a computer by using a standard modem cable. TxD describes the sending, RxD the receiving line of the GPS163xHS.

RS-232
COM0 and COM1

RS-485
COM1 (option)

Replacing the lithium battery

The life time of the lithium battery on the board is at least 10 years. If the need arises to replace the battery, the following should be noted:

ATTENTION!

Danger of explosion in case of inadequate replacement of the lithium battery. Only identical batteries or batteries recommended by the manufacturer must be used for replacement. The waste battery must be disposed as proposed by the manufacturer of the battery.

CE label

This device conforms to the directive 89/336/EWG on the approximation of the laws of the Member States of the European Community relating to electromagnetc compatibility.

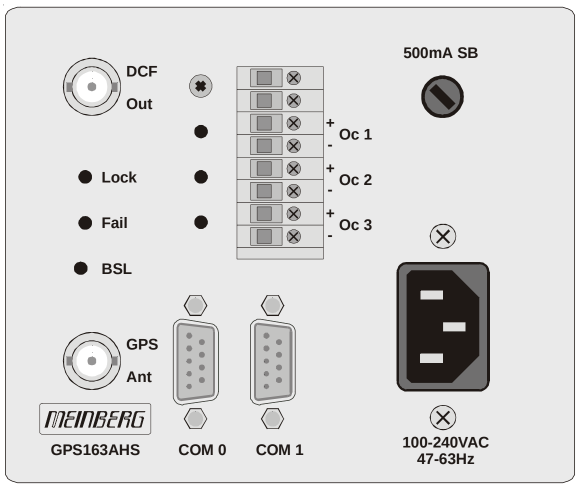
Technical specifications GPS163xHS

RECEIVER:	6 channel C/A code receiver with external antenna/converter unit
ANTENNA:	Antenna/converter unit with remote power supply refer to chapter "Technical specifications of antenna"
ANTENNA INPUT:	Antenna circuit dc-insulated; dielectric strength: 1000V⎓ Length of cable: refer to chapter "Mounting the antenna"
TIME TO SYNCHRO-NIZATION:	one minute with known receiver position and valid almanac 12 minutes if invalid battery buffered memory
BATTERY BACKUP:	storage of pulse configuration and important GPS-system data in the internal RAM, backed-up by lithium battery lifetime of battery 10 years min.
PULSE OUTPUTS:	three programmable outputs insulation via optocouplers U_{CEmax} = 55 V, I_{Cmax} = 50 mA, P_{tot} = 150 mW, V_{iso} = 5000 V pulse delay: t_{on} e.g. 20 µsec (I_C = 10 mA) t_{off} e.g. 3 µsec (I_C = 10mA) default settings: all pulse outputs inactive mode of operation: 'if sync' option: PhotoMOS relays U_{max} = 400 V, I_{max} = 150 mA, P_{tot} = 360 mW, V_{iso} = 1500 V
ACCURACY OF PULSES:	better than ±1 µsec after synchronization and 20 minutes of operation better than ±3 µsec during the first 20 minutes of operation

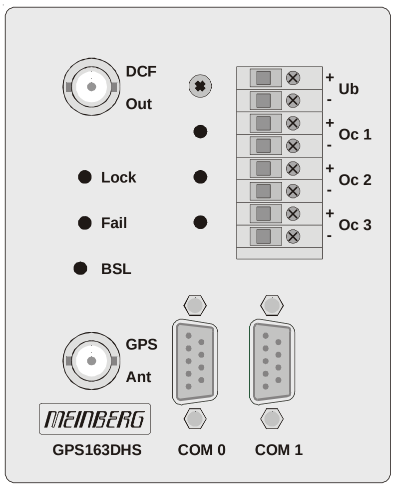
SERIAL PORTS:	2 independant asynchronous serial ports COM0 (RS-232) Baud Rate: 300 up to 19200 Framing: 7N2, 7E1, 7E2, 8N1, 8N2, 8E1 COM1 (RS-232, optional RS-485) Baud Rate: 300 up to 19200 Framing: 7E2, 8N1, 8O1, 8E1 time string selectable for COM0 and COM1 'standard Meinberg', 'SAT', 'Uni Erlangen (NTP)' default settings: COM0: 19200, 8N1 COM1: 9600, 8N1 'standard Meinberg' for COM0 and COM1 time string per second mode of operation 'if sync'
DCF77 EMULATION:	AM-modulated 77.5 kHz carrier frequency usable as replacement for a DCF77 antenna output level approximately -55 dBm (unmodulated)
STATUS INDICATION:	receiver status: Lock: the reciever was able to compute its position after power-up Fail: the receiver is asynchronous to the GPS-system status of the pulse outputs: a burning LED indicates the active state of the corresponding optocoupler
POWER REQUIREMENTS:	GPS163DHS: 19-72 VDC, e.g. 3.6W DC-insulation 1.5 KV GPS163AHS: 100-240 VAC, 47-63 Hz fuse: 500mA

DIMENSION:	GPS163DHS: 105 mm x 85 mm x 104 mm (H x B x T) GPS163AHS: 105 mm x 125.5 mm x 104 mm (H x B x T)
CONNECTORS:	coaxial BNC connectors for antenna/converter unit and AM-modulated DCF77 output terminal block for connection of pulse outputs and power supply (GPS163DHS only) power cord receptacle for AC-line (GPS163AHS only)
AMBIENT TEMPERATURE:	0 ... 50°C
HUMIDITY:	85% max.

Front views



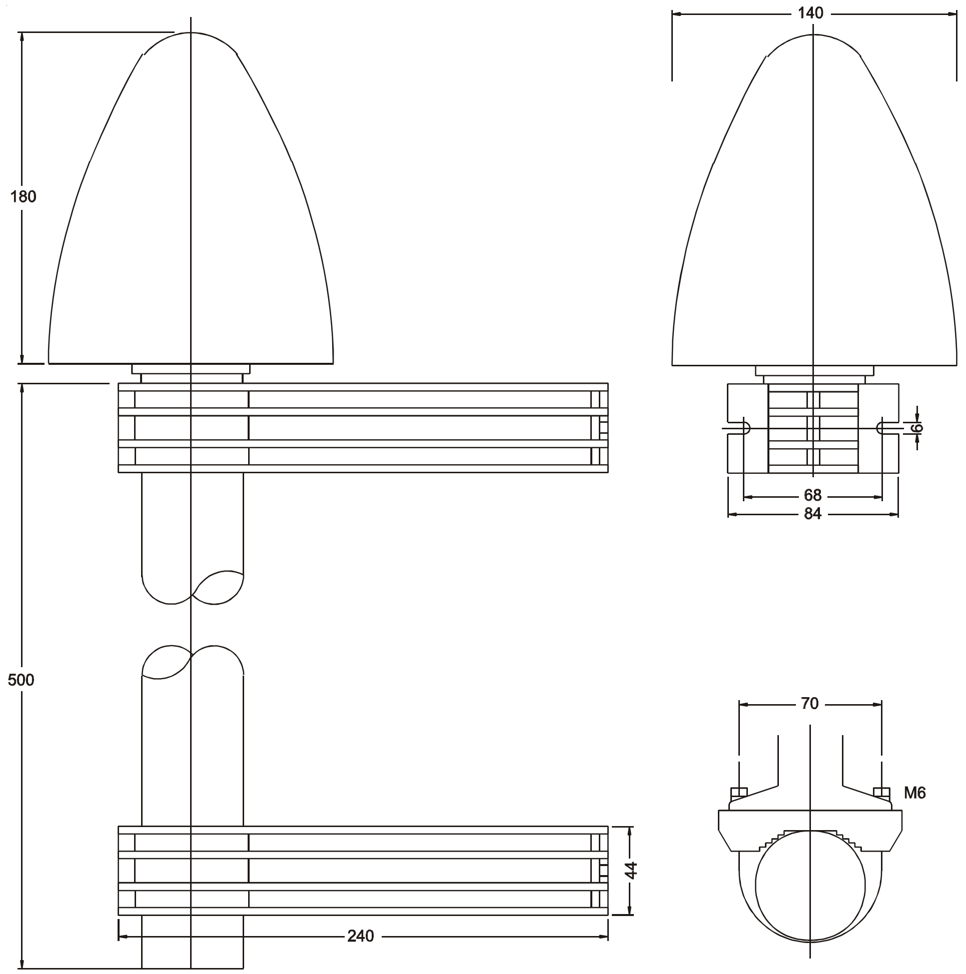
GPS163AHS



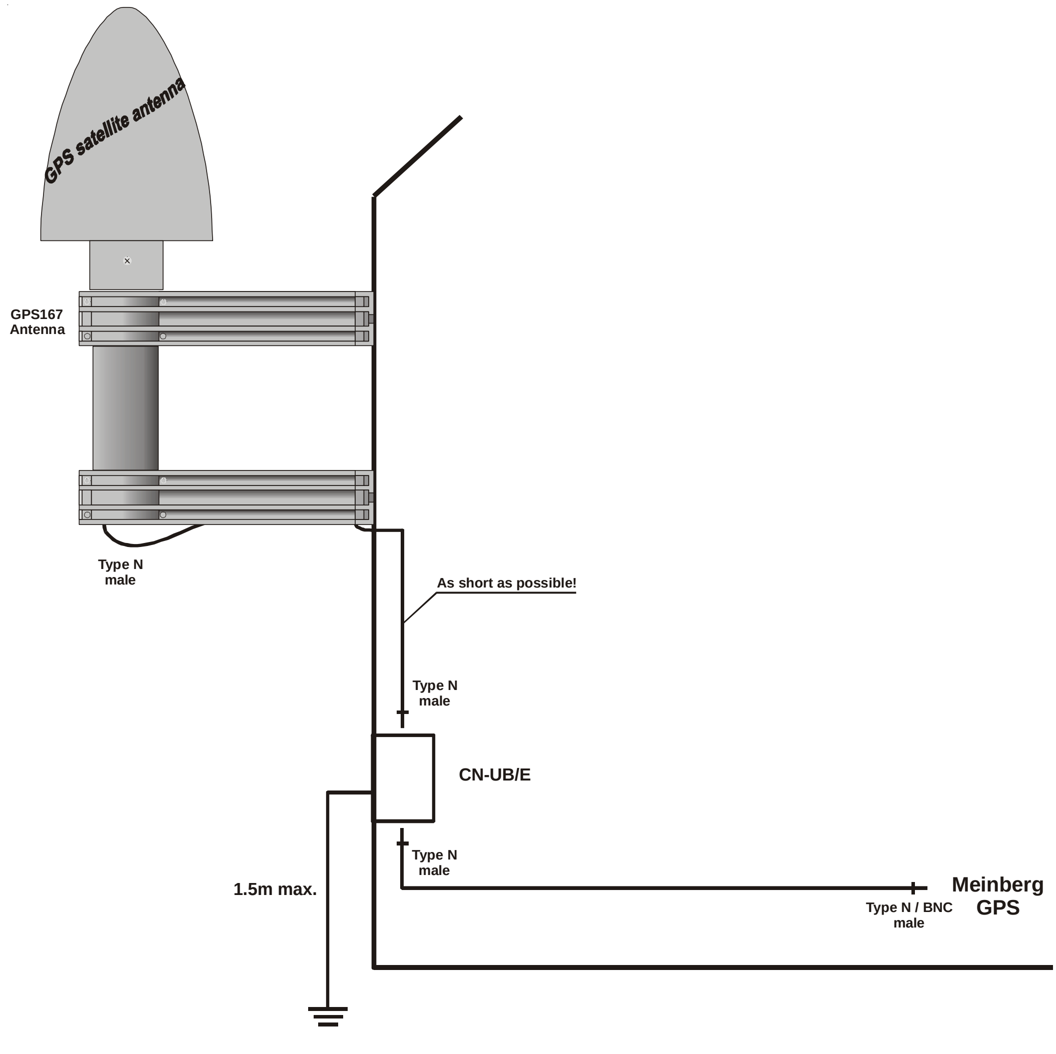
GPS163DHS

Technical specifications of antenna

ANTENNA:	dielectrical patch antenna, 25 x 25mm
	receive frequency: 1575.42 MHz
	bandwidth: 9 MHz
CONVERTER:	local oscillator to converter frequency: 10 MHz
	first IF frequency: 35.4 MHz
POWER REQUIREMENTS:	12V ... 18V, @ 100mA (provided via antenna cable)
CONNECTOR:	coax type N, female
AMBIENT TEMPERATURE:	-25 ... +65°C
HOUSING:	ABS plastic case for outdoor installation (IP56)
PHYSICAL DIMENSION:	



Assembly with CN-UB/E (CN-UB-280DC)



Format of the Meinberg standard time string

The Meinberg standard time string is a sequence of 32 ASCII characters starting with the STX (start-of-text) character and ending with the ETX (end-of-text) character. The format is:

<STX>D:*dd.mm.yy*;T:*w*;U:*hh.mm.ss*;*uvxy*<ETX>

The letters printed in *italics* are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<STX> Start-Of-Text (ASCII code 02h)

dd.mm.yy the current date:

dd	day of month	(01..31)
mm	month	(01..12)
yy	year of the century	(00..99)

w the day of the week (1..7, 1 = Monday)

hh.mm.ss the current time:

hh	hours	(00..23)
mm	minutes	(00..59)
ss	seconds	(00..59, or 60 while leap second)

uv clock status characters:

u: ‘#’ clock has not synchronized after reset
‘ ‘ (space, 20h) clock has synchronized after reset

v: different for DCF77 or GPS receivers:

‘*’ DCF77 clock currently runs on XTAL
GPS receiver has not checked its position

‘ ‘ (space, 20h) DCF77 clock is sync'd with transmitter
GPS receiver has determined its position

x time zone indicator:

‘U’	UTC	Universal Time Coordinated, formerly GMT
‘ ‘	MEZ	European Standard Time, daylight saving disabled
‘S’	MESZ	European Summertime, daylight saving enabled

y anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:

‘!’ announcement of start or end of daylight saving time
‘A’ announcement of leap second insertion
‘ ‘ (space, 20h) nothing announced

<ETX> End-Of-Text (ASCII code 03h)

Format of the SAT time string

The SAT time string is a sequence of 29 ASCII characters starting with the STX (start-of-text) character and ending with the ETX (end-of-text) character. The format is:

<STX>*tt.mm.jj*/*w*/*hh.mm.ss*ME*zzxy*<CR><LF><ETX>

The letters printed in *italics* are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<STX> Start-Of-Text (ASCII code 02h)

dd.mm.yy the current date:

dd	day of month	(01..31)
mm	month	(01..12)
yy	year of the century	(00..99)

w the day of the week (1..7, 1 = Monday)

hh.mm.ss the current time:

hh	hours	(00..23)
mm	minutes	(00..59)
ss	seconds	(00..59, or 60 while leap second)

zz time zone indicator:

‘Z ‘	MEZ	European Standard Time, daylight saving disabled
‘SZ’	MESZ	European Summertime, daylight saving enabled

x clock status characters:

‘*’ DCF77 clock currently runs on XTAL
GPS receiver has not checked its position

‘ ‘ (space, 20h) DCF77 clock is sync'd with transmitter
GPS receiver has determined its position

y anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:

‘!’ announcement of start or end of daylight saving time
‘ ‘ (space, 20h) nothing announced

<CR> Carriage return (ASCII code 0Dh)

<LF> Line feed (ASCII code 0Ah)

<ETX> End-Of-Text (ASCII code 03h)

Format of the time string Uni Erlangen (NTP)

The time string Uni Erlangen (NTP) of a **GPS-clock** is a sequence of 66 ASCII characters starting with the STX (start-of-text) character and ending with the ETX (end-of-text) character. The format is:

<STX>tt.mm.jj; w; hh:mm:ss; voo:oo; acdfg i;bbb.bbbbn lll.llle hhhh**m*****<ETX>***

The letters printed in *italics* are replaced by ASCII numbers whereas the other characters are part of the time string. The groups of characters as defined below:

<STX> Start-Of-Text (ASCII code 02h)

dd.mm.yy the current date:
- *dd* day of month (01..31)
- *mm* month (01..12)
- *yy* year of the century (00..99)

w the day of the week (1..7, 1 = Monday)

hh.mm.ss the current time:
- *hh* hours (00..23)
- *mm* minutes (00..59)
- *ss* seconds (00..59, or 60 while leap second)

v sign of the offset of local timezone related to UTC

oo:oo offset of local timezone related to UTC in hours and minutes

ac clock status characters:
- *a*: '#' clock has not synchronized after reset
- ' ' (space, 20h) clock has synchronized after reset

- *c*: '*' GPS receiver has not checked its position
- ' ' (space, 20h) GPS receiver has determined its position

d time zone indicator:
- 'S' MESZ European Summertime, daylight saving enabled
- ' ' MEZ European Standard Time, daylight saving disabled

f anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:
- '!' announcement of start or end of daylight saving time
- ' ' (space, 20h) nothing announced

g anouncement of discontinuity of time, enabled during last hour before discontinuity comes in effect:
- 'A' announcement of leap second insertion
- ' ' (space, 20h) nothing announced

i	leap second insertion ‘L’ leap second is actually inserted (active only in 60th sec.) ‘ ‘ (space, 20h) no leap second is inserted
bbb.bbbb	latitude of receiver position in degrees leading signs are replaced by a space character (20h)
n	latitude, the following characters are possible: ‘N’ north of equator ‘S’ south of equator
lll.llll	longitude of receiver position in degrees leading signs are replaced by a space character (20h)
e	longitude, the following characters are possible: ‘E’ east of Greenwich ‘W’ west of Greenwich
hhhh	altitude above sea level in meters leading signs are replaced by a space character (20h)
<ETX>	End-Of-Text (ASCII-code 03h)

Format of the NMEA (RMC) string

The NMEA String is a sequence of 65 ASCII characters starting with the ‘$’ character and ending with the characters CR (carriage return) and LF (line-feed). The format is:

$GPRMC,hhmmss.ss,A,bbbb.bb,n,lllll.ll,e,0.0,0.0,ddmmyy,0.0,a*hh<CR><LF>

The letters printed in *italics* are replaced by ASCII numbers or letters whereas the other characters are part of the time string. The groups of characters as defined below:

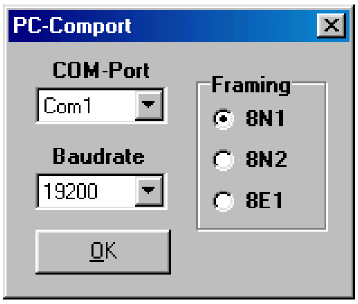
$	start character (ASCII-Code 24h)		
hhmmss.ss	the current time:		
	hh	hours	(00..23)
	mm	minutes	(00..59)
	ss	seconds	(00..59, or 60 while leap second)
	ss	fractions of seconds	(1/10 ; 1/100)
A	Status	(A = time data valid)	
		(V = time data not valid)	
bbbb.bb	latitude of receiver position in degrees leading signs are replaced by a space character (20h)		
n	latitude, the following characters are possible:		
	‘N’	north of equator	
	‘S’	south d. equator	
lllll.ll	longitude of receiver position in degrees leading signs are replaced by a space character (20h)		
e	longitude, the following characters are possible:		
	‘E’	east of Greenwich	
	‘W’	west of Greenwich	
ddmmyy	the current date:		
	dd	day of month	(01..31)
	mm	month	(01..12)
	yy	year of the century	(00..99)
a	magnetic variation		
hh	checksum (EXOR over all characters except ‘$’ and ‘*’)		
<CR>	carriage-return; ASCII-Code 0Dh		
<LF>	line-feed; ASCII-Code 0Ah		

Diskette with Windows Software GPSMON32

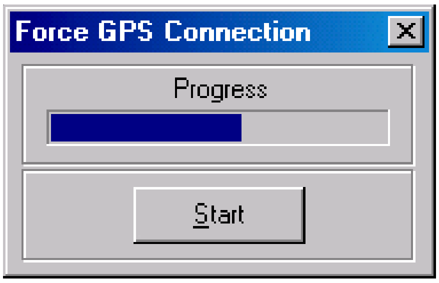
The program GPSMON32

The program GPSMON32 can be used to monitor and program all essential functions of Meinberg GPS-Receivers. The Software is executable under Win9x/2k/NT. To install GPSMON32 just run Setup.exe from the included diskette and follow the instructions of the setup program.

To obtain a connection between your PC and the GPS-receiver, connect the receivers COM0 port to a free serial port of your PC. The PCs comport used by the program GPSMON32 can be selected in submenu **'PC-Comport'** in menu **'Connection'**.



Also transfer rate and framing used by the program are selected in this menu. Communication between the clock and the PC comes about, only if the GPS serial port is configured in the same way as the PCs comport. You can enforce an access, if the GPS serial port is not configured with appropriate parameters for communication. Select the menu item '**Enforce Connection**' in menu **'Connection'** and click **'Start'** in the appearing window. Some firmware versions of GPS167 do not support this way of setting up a connection. If '**Enforce Connection**' doesn't succeed apparently, please change the serial port parameter of GPS COM0 manually to the PCs parameters.



Online Help

The online help can be started by clicking the menu item 'Help' in menu Help. In every program window a direct access to a related help topic can be obtained by pressing F1. The help language can be selected by clicking the menu items Deutsch/Englisch in the Help Menu.