HS16H

General

The corresponding GPS receivers will be labeled with *HSx* in the following text. They differ essentially in the corresponding integrated GPS module.
The *HSx* box processes the NMEA sentences VTG and GGA of the integrated GPS receiver unit. Beside the serial NMEA output (with 115200 baud), it additionally provides the horizontal speed, driving direction, height, position, longitudinal acceleration, angular speed, traverse acceleration, slope angle, curve radius, total acceleration and quality of the GPS measurement data via a three-line display, via a voltage output, via a frequency output and via a CAN bus, where interpolated values are used to output the corrected speed, the acquired acceleration and the driven distance every 20 ms. Furthermore, driving performance measurements can be made directly.

Figure 1: GPS receiver HS16H with antenna.

Scope of Delivery

The scope of delivery of *HSx* contains:

- *HSx* box
- Connection cable with open ends for power supply and CAN bus
- GPS antenna for the *HSx* box
- USB connection cable (virtual COM port)
- Adapter cable *GPS-Prog* for USB connection cable to program and configure the GPS receiver unit (which is usually not necessary), and **[not for *HsxD/HsxF*[1]]** for the NMEA ouptut
- **[*HsxD/HsxF* only:]** Adapter cable *GPS-NMEA* for USB connection cable to connect with the NMEA output

1 *HSxD/HSxF*: GPS receiver HS10D, HS20D, HS20F, HS50D or HS50F

Accessory

Not within the scope of delivery are:

- vacuum cup *VC10*
- power adapter *PA*
- low speed CAN adapter *LCC719*

Voltage Output

The voltage consists of a 12-bit D/A converter which can output voltages within the range from 0 V to 5 V. It has an internal resistance R_i of 1 kΩ. The linearity and offset error are max. 20 mV. At the moment, the current total acceleration is output as a linear voltage signal:
$0\ m/s^2 \mapsto 2.5\ V$ and $15\ m/s^2 \mapsto 5\ V$.

The voltage signal is at the LCD page *longitudinal acceleration* the magnitude of signal *GS2_Acceleration*, at the LCD page *traverse acceleration* the magnitude of signal *GS4_TraverseAcceleration*, and at the other LCD pages the signal *GS4_TotalAcceleration*, which has a typical signal delay of 450 ms (at T_{acc} = 360 ms).

Frequency Output

The frequency output provides a square-wave signal with 0 V or 5 V levels and a 50 % duty cycle. It has an internal resistance R_i of 1 kΩ. At the moment, the current speed is output as a linear frequency signal with 10 Hz per km/h and with an offset of 100 Hz:
0 km/h $\mapsto$ 100 Hz and 100 km/h $\mapsto$ 1100 Hz.

The frequency signal is the signal *GS3_SpeedInt*, which is updated every 20 ms, and which has a typical signal delay of 180 ms.

Operating Modes

The *PAGE* button is used to switch the pages of the LCD display. With releasing the button after holding it down for a longer period of time, sometimes a corresponding action (usually a reset) is triggered, or, at the last page (with the NMEA message counters), the background light is turned on and off.

After turning on, the display page *Driving dynamics* is automatically selected as soon as the GPS signals are valid.

Info:

`HS16H V3.0.0`	ascertained device type / firmware version
`Bat:  12.0 V`	measured power supply
`23:59:59  ↑■`	local time

Driving dynamics:

`100 kph 240m`	speed / height
`B 9.8  R 0.1`	longitudinal acc. / traverse acceleration
`200m  1° 8↑■`	curve radius / slope angle / num. of satellites

GPS status:

`100.00 km/h`	speed
`240 m 359°`	height / direction
`Q2 S8 H1.0↑■`	quality / number of satellites / HDOP

Longitudinal acceleration:

`100.00 km/h`	speed
`-9.81 m/s²`	acceleration
`70 m ↑■`	distance

Traverse acceleration:

`100.00 km/h`	speed
`0.14 m/s²`	traverse acceleration
`200 m  1°T↑■`	curve radius / slope angle

Position:

`50.00000 °N`	latitude
`10.00000 °E`	longitude
`240.0 m ↑■`	height

Acceleration measurement (A: 0…100 km/h):

Waiting for satellite signals:

`43.85 km/h`	current speed
`Waiting for` `sat      A↑■`	measurement A

Preparing measurement:

`43.85 km/h`	current speed
`Waiting for` `< 5 km/h A↑■`	measurement A

Waiting for start of measurement:

`0.00 km/h`	current speed
`Waiting for` `≥ 5 km/h  A↑■`	measurement A

Measurement in progress:

`51.71 km/h`	current speed
`30.58 m`	progressing distance
`4.07 s  A↑■`	progressing time / measurement A

Result:

`2.97 m/s²`	average acceleration
`146.11 m`	required distance
`9.34 s  A↑■`	required time / measurement A

Braking measurement (B: 100…0 km/h):

Waiting for satellite signals:

`43.85 km/h`	current speed
`Waiting for` `sat      B↑■`	measurement B

Preparing measurement:

`43.85 km/h`	current speed
`Waiting for` `>100km/h B↑■`	measurement B

Waiting for start of measurement:

`123.51 km/h`	current speed
`Waiting for` `≤100km/h  B↑■`	measurement B

Measurement in progress:

`48.95 km/h`	current speed
`33.57 m`	progressing distance
`1.62 s  B↑■`	progressing time / measurement B

Result:

`-8.52 m/s²`	average acceleration
`43.89 m`	required distance
`3.26 s  B↑■`	required time / measurement B

400 m measurement (D: 0…400 m):

Waiting for satellite signals:

`43.85 km/h`	current speed
`Waiting for` `sat      D↑■`	measurement D

Preparing measurement:

`43.85 km/h`	current speed
`Waiting for` `< 5 km/h D↑■`	measurement D

Waiting for start of measurement:

`0.00 km/h`	current speed
`Waiting for` `≥ 5 km/h  D↑■`	measurement D

Measurement in progress:

`50.21 km/h`	current speed
`13.14 m`	progressing distance
`1.95 s  D↑■`	progressing time / measurement D

Result:

`4.68 m/s²`	average acceleration
`197.40 km/h`	speed after 400 m
`11.71 s  D↑■`	required time / measurement D

NMEA sentences:

`Tv:    60 ms`	ascertained gap between VTG sentences
`Tp:    60 ms`	ascertained gap between GGA sentences
`Cv01 Cp01 ↑■`	sentence counters (VTG / GGA)

Driving Performance Meas.

The different measurements are constantly running in the background, and can be reset at any time by pressing the button longly (at the corresponding measurement page). The acceleration and 400 m measurement are reset together. Whereas the braking measurement is also automatically reset (when driving with more than 100 km/h). The measurements start (or end) at 5 km/h, where the time and distance difference (within the velocity-time graph) to 10 km/h is used for linear extrapolation to 0 km/h:

$\Delta t_{0\ldots5\,km/h} = |\, t_{10\,km/h} - t_{5\,km/h} \,|$

$\Delta s_{0\ldots5\,km/h} = (5\,km/h \cdot \Delta t_{0\ldots5\,km/h}) / 2$

Display (HDOP)

The HDOP value is displayed on each page in the lower right as a level meter:

Bars	HDOP	(ΔHDOP)	Comment
7	0.0 … 1.3	(+1.3)	best signal
6	1.4 … 1.8	(+0.4)	$1.4 \approx 1.3875^1$
5	1.9 … 2.6	(+0.7)	$1.9 \approx 1.3875^2$
4	2.7 … 3.6	(+0.9)	$2.7 \approx 1.3875^3$
3	3.7 … 5.0	(+1.3)	$3.7 \approx 1.3875^4$
2	5.1 … 7.0	(+1.9)	$5.1 \approx 1.3875^5$
1	7.1 … 9.8	(+2.7)	$7.1 \approx 1.3875^6$
0	9.9 … 9.9	(+0.0)	no satellites

Display (Direction)

The driving direction of the GPS antenna is displayed directly left to the HDOP level meter as an arrow:

Arrow	Direction		Comment
↑	337.5° … 22.49°	N	
↗	22.5° … 67.49°	NE	
→	67.5° … 112.49°	E	
↘	112.5° … 157.49°	SE	
↓	157.5° … 202.49°	S	
↙	202.5° … 247.49°	SW	
←	247.5° … 292.49°	W	
↖	292.5° … 337.49°	NW	
	(360°)		no direction

Signal Propagation Delay

Symbol	Description
T_{10}	Repeat rate of 100 ms
T_{16}	Repeat rate of 60 ms
T_{20}	Repeat rate of 50 ms
T_{50}	Repeat rate of 20 ms
T_{acc}	Time window setting for the acceleration calculation (= 400 ms).
$T_{acc,x}$	Time window for the acceleration calculation: $T_{acc,x} = \min(i \cdot T_x \mid i \cdot T_x \geq T_{acc})$ with arbitrary integer i from 1 to 51 for the corresponding *HSx* box with $x \in \{ 10, 16, 20, 50 \}$
$T_{avg,x}$	Time window for moving average: $T_{avg,x} = T_{acc,x} - T_x$ where $x \in \{ 10, 16, 20, 50 \}$
$T_{d,acc,x}$	Delay of the acceleration signal: $T_{d,acc,x} = T_{acc,x} - T_x/2$ where $x \in \{ 10, 16, 20, 50 \}$
$T_{d,avg,x}$	Delay of average signal: $T_{d,avg,x} = (T_{acc,x} - T_x)/2$ where $x \in \{ 10, 16, 20, 50 \}$
$T_{GPS,x}$	General delay of the GPS signal for the corresponding *HSx* box with $x \in \{ 10, 16, 20, 50 \}$

Signal Propagation Delay of HS10G

Signal name	Typical signal propagation delay	
GS2_Acceleration	510 ms	$T_{GPS,16} + T_{d,acc,16}$
GS3_AccelerationInt	570 ms	$T_{GPS,16} + T_{d,acc,16} + T_{16}$
GS3_DistanceInt	180 ms	$T_{GPS,16} + T_{16}$
GS3_SpeedInt	180 ms	$T_{GPS,16} + T_{16}$
GS4_…	510 ms	$T_{GPS,16} + T_{d,acc,16}$
All further GPS signals	120 ms	$T_{GPS,16}$
T_{16} | $T_{GPS,16}$ | T_{acc}	60 ms | 120 ms | 420 ms	
$T_{acc,16}$ | $T_{d,acc,16}$	420 ms | 390 ms	
$T_{avg,16}$ | $T_{d,avg,16}$	360 ms | 180 ms	

CAN

CAN default settings

CAN library	HSx 1.2
CAN baud rate	500 kbps
CAN sample point	80 %
Message basis ID	600h (11-bit std ID)
Message IDs	600h … 607h

Bit numbering

Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
7…0	15…8	23…16	31…24	39…32	47…40	55…48	63…56

A *HSx* CAN signal allocates the bit range (within the CAN message) from its start bit to start bit + bit length - 1. The bit numbering corresponds to the weight of the bits of an unsigned 64-bit number (with Intel byte order).

Message GS1 (ID: basis ID + 0 = 600h / Length: 8 bytes / Repetition rate: after each correctly received VTG sentence)

S[1]	*DL*	**Description**
0	u8	**GS1_Counter:** This counter is incremented with each new *GS1* message. The counter restarts after 255 with 0.
8	u8	**GS1_Flags:** Bit mask with following assingment: 1: *GS1_SpeedRaw* not updated 2: *GS1_TrackRaw* not updated 4: *GS4_SpeedAvg* not updated 8: *GS2_Acceleration* not updated 16: Waiting for synchronization for signals *GS2_Acceleration, GS3_…*, and *GS4_SpeedAvg.* 32: VTG sentence received too early or too late.
16	u16	**GS1_SpeedRaw:** Raw (= untreated) speed signal (= v_R), directly taken from VTG sentence with a resolution of 0.01 km/h per bit.
32	u16	**GS1_TrackRaw:** Raw driving direction (= track made good) with a resolution of 0.01° per bit.
48	u16	**GS1_Track:** Driving direction after acceptance check ($v_R \geq v_{T,min}$ where $v_{T,min}$ = 2 km/h) with a resolution of 0.01° per bit.

Message GS2 (ID: basis ID + 1 = 601h / Length: 8 bytes / Repetition rate: after each correctly received VTG sentence)

S	*DL*	**Description**
0	u16	**GS2_Speed:** Speed signal (= *v*) after acceptance check, standing detection ($v_R \geq v_{min}$ with v_{min} = 0.5 km/h) and limited acceleration ($\lvert a \rvert \leq a_{max}$ where a_{max} = 19.62 m/s²) with a resolution of 0.01 km/h per bit.
16	s16	**GS2_Acceleration:** Acceleration of the speed signal *v* with a resolution of 0.01 m/s² per bit.
32	u32	**GS2_Distance:** Absolute distance counter since *HSx* box reset with a resolution of 0.01 m per bit.

Message GS3 (ID: basis ID + 2 = 602h / Length: 8 bytes / Repetition rate: 20 ms (10 ms by choice))

S	*DL*	**Description**
0	u16	**GS3_SpeedInt:** Interpolated speed signal with a resolution of 0.01 km/h per bit. This signal is linear interpolated from the last two values of signal *GS2_Speed*.
16	s16	**GS3_AccelerationInt:** Interpolated acceleration signal with a resolution of 0.01 m/s² per bit. This signal is linear interpolated from the last two values of signal *GS2_Acceleration*.
32	u32	**GS3_DistanceInt:** Interpolated distance with a resolution of 0.01 m per bit. This signal is linear interpolated from the last two values of signal *GS2_Distance*.

Message GS4 (ID: basis ID + 3 = 603h / Length: 8 bytes / Repetition rate: after each correctly received VTG sentence)

S	*DL*	**Description**
0	s16	**GS4_AngularSpeed:** Angular speed with a resolution of 0.001 Hz per bit.
16	s16	**GS4_TraverseAcceleration:** Traverse acceleration a_T with a resolution of 0.01 m/s² per bit.
32	u16	**GS4_Radius:** Curve radius with a resolution of 0.1 m per bit.
48	u8	**GS4_SlopeAngle:** Slope angle with a resolution of 0.25° per bit.
56	u8	**GS4_TotalAcceleration:** Total acceleration, calculated from $\sqrt{a^2+a_T^2}$, with a resolution of 0.1 m/s² per bit.

1 S: start bit
D: data type (u – unsigned Intel / s – signed Intel)
L: bit length

Message GP1 (ID: basis ID + 4 = 604h / Length: 8 bytes / Repetition rate: after each correctly received GGA sentence)

S	*D L*	Description
0	u8	**GP1_Counter:** This counter is incremented with each GP1 message. The counter restarts after 255 with 0.
8	u4	**GP1_Qual:** GPS quality indicator *HS10G*: 0: GPS data not available (or invalid) 1: Valid GPS data 2: Valid DGPS data 6: Dead reckoning mode
12	u4	**GP1_Flags:** Bit mask with following assignment: 1: *GP1_Sat* not updated 2: *GP1_HDOP* not updated 4: *GP1_Synch* not updated 8: *GP1_HeightRaw* not updated
16	u6	**GP1_Sat:** Number of satellites in use. May be different to the number in view.
22	u2	**GP1_Flags2:** Bit mask with following assignment: 1: *GP2_LatitudeRaw* not updated 2: *GP2_LongitudeRaw* not updated
24	u8	**GP1_HDOP:** Horizontal dilution of precision with a resolution of 0.1 per bit.
32	u16	**GP1_Synch:** Part of the UTC time of the GGA sentence. Note, that only the backmost part m:ss.ss from the UTC time hh:mm:ss.ss is used with a resolution of 0.01 s per bit.
48	u16	**GP1_HeightRaw:** Raw antenna altitude above mean sea level with a resolution of 0.1 m per bit, and with an offset of -500 m.

Message GP2 (ID: basis ID + 5 = 605h / Length: 8 bytes / Repetition rate: at the earliest after each correctly received GGA sentence)

S	*D L*	Description
0	s32	**GP2_LatitudeRaw:** Raw latitude with a resolution of 1/600000 °N per bit.
32	s32	**GP2_LongitudeRaw:** Raw longitude with a resolution of 1/600000 °E per bit.

Message GP3 (ID: basis ID + 6= 606h / Lenth: 8 bytes / Repetition rate: at the earliest after each correctly received GGA sentence)

S	*D L*	Description
0	s32	**GP3_Latitude:** Latitude with a resolution of 1/600000 °N per bit. This signal is not updated when no satellites are available.
32	s32	**GP3_Longitude:** Longitude with a resolution of 1/600000 °E per bit. This signal is not updated when no satellites are available.

Message GP4 (ID: basis ID + 7= 607h / Length: 8 bytes / Repetition rate: after each correctly received GGA sentence)

S	*D L*	Description
0	u8	**GP4_VBat:** Measured supplying voltage of the *HSxD* with a resolution of 0.2 V per bit (and internally measured up to 35 V).
8	u8	**GP4_Sec:** Local time with a resolution of 1 s per bit in the range of 0…59 s.
16	u8	**GP4_Min:** Local time with a resolution of 1 minute per bit in the range of 0…59 minutes.
24	u8	**GP4_Hours:** Local time with a resolution of 1 hour per bit in the range of 0…23 hours.
32	u8	**GP4_UTCMin:** UTC time with a resolution of 1 minute per bit in the range of 0…59 minutes.
40	u8	**GP4_UTCHours:** UTC time with a resolution of 1 hour per bit in the range of 0…23 hours.
48	u16	**GP4_UTC:** UTC time with a resolution of 2 s per bit in the range of 0…23 hours.

Connectors

The socket and plugs of the *HSx box* are from the Binder Series 719. The socket pins are (in frontal view) numbered clockwise, starting with the first pin after the notch. The plug pins are correspondingly numbered anti-clockwise.

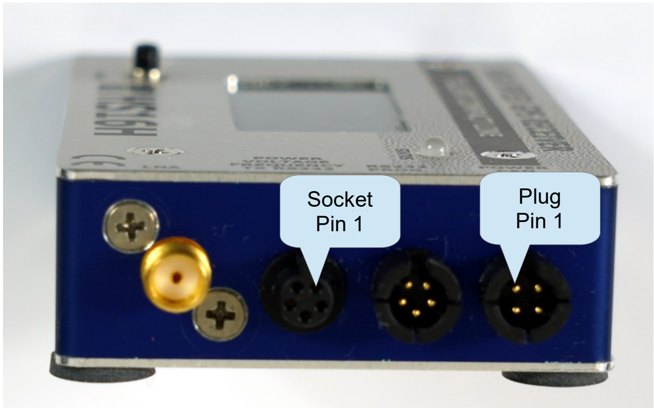

Figure 2: Connectors of the GPS receiver HS16H.

LNA: The LNA connector is of type SMA, and connects the *HSxD* with an active GPS antenna. It is temporarily short-circuit proof due to its internal resistance of *Ri* = 50 Ω. The active GPS antenna is supplied with 5 V DC.

POWER/CAN: This plug provides the *HSx* box with power and connects it with the CAN bus.

Pin	Assignment
1	Power supply (from 8 V DC to 30 V DC; inverse-polarity and voltage spike protected) (Wire color: brown)
2	Ground (Wire color: white)
3	CAN_L (Wire color: blue)
4	CAN_H (Wire color: black)

Note: The *HSx* box does not possess a CAN bus termination resistor. Therefore, it must be made sure that the CAN bus is properly ended, twice with a 120 Ω resistor (, or once with a 60 Ω resistor,) between CAN_L and CAN_H.

RS232/PROG: This plug connects the *HSx* box with two serial ports.

Pin	Assignment
1	Serial transmit wire to program the *HSx* box
2	Ground (internally connected with pin 2 of connector POWER/CAN)
3	Serial receive wire to program the *HSx* box
4	Serial transmit wire to program and to configure the GPS receiver unit, **[not for *HSxD/HSxF*:]** and for output of the NMEA messages with 115200 baud (internally connected with pin 5 of connector POWER/VOLTAGE/FREQUENCY/TX RS232)
5	Serial receive wire to program and to configure the GPS receiver unit

POWER/VOLTAGE/FREQUENCY/TX RS232: This socket is optionally used to supply power to the *HSx* box, and it also provides the analog, digital, and NMEA output.

Pin	Assignment
1	Power supply (from 8 V DC to 30 V DC; inverse-polarity and voltage spike protected; internally connected with pin 1 of connector POWER/CAN)
2	Ground (internally connected with pin 2 of connector POWER/CAN)
3	Voltage output (0…5 V; internal resistance *Ri* = 1 kΩ; 12-bit D/A converter; linearity and offset error: max. 20 mV)
4	Digital output (0 V / 5 V; 50 % duty cycle; internal resistance *Ri* = 1 kΩ)
5	Serial transmit wire (Output of the NMEA sentences at 115200 baud)

Technical Data (HS*x* Box)

Property	Description
Box length/width:	84 mm × 52 mm (+ 6 mm for connectors)
Power supply:	From 8 V DC to 30 V DC
NMEA output:	VTG, GGA and ZDA sentences with 115200 bps.
CAN:	1 high speed CAN channel (CAN 2.0B) with a max. baud rate of 1 Mbps
Analog output signal::	0…5 V 12-bit D/A converter Internal resistance *Ri* = 1 kΩ (Linearity and offset error: max. 20 mV)
Digital output signal:	Frequency signal (square wave with 0 V / 5 V, and with a 50 % duty cycle) Internal resistance *Ri* = 1 kΩ
LED (Status):	**Green:** GPS receiver unit delivers valid values. **Red:** GPS receiver unit not yet ready.
Button (Page):	Button to switch the LCD pages, and when pressed longer, to trigger an action (usually a reset), or to turn the background light on and off (at the last LCD page).

HS16H

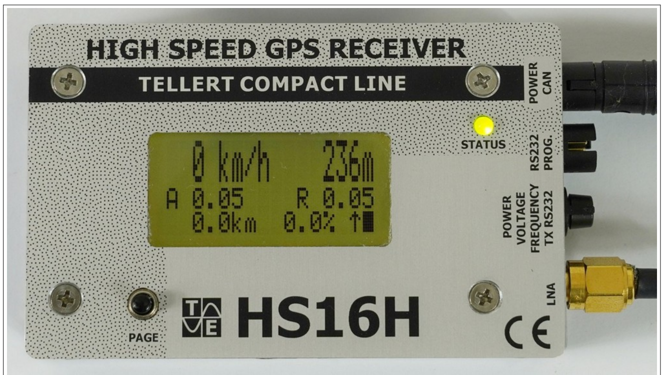

Figure 3: GPS receiver HS16H.

Further technical data:

Poperty	Description
Box height:	19 mm (+ 3 mm for buttons/burlings)
Typical weight:	102 g
Display:	3-line LCD display with 16 characters per line
Typical current consumption (without backlight):	100 mA (90 mA) at 8 V DC 65 mA (58 mA) at 12 V DC 50 mA (45 mA) at 16 V DC 36 mA (34 mA) at 24 V DC 31 mA (29 mA) at 30 V DC
Typical power consumption (without backlight):	0.8 W (0.7 W) at 8 V DC 0.8 W (0.7 W) at 12 V DC 0.8 W (0.7 W) at 16 V DC 0.9 W (0.8 W) at 24 V DC 0.9 W (0.9 W) at 30 V DC
Refresh rate:	16⅔ Hz
GPS module:	NEO-M8Q oder NEO-M8N (from u-blox)
Presettings of the GPS module:	SBAS deactivated; ≤ 9 satellites; *portable* platform (speed ≤ 1116 km/h; altitude speed ≤ 180 km/h; altitude ≤ 12 km)

GPS receiver unit (according to u-blox):

Property	Description
Chip set:	u-blox NEO-M8Q or NEO-M8N
Sensitivity:	Tracking & navigation: -164 dBm Reacquisition: -159 dBm Cold/warm start: -147 dBm Hot start: -156 dBm
First sample:	After 1 s (and in worst case after 30 s)
Speed accuracy:	0.05 m/s (50 % @ 30 m/s)
Direction accuracy:	0.3° (50 % @ 30 m/s)
Position accuracy:	2.5 m (CEP, 50 %, 24 hours static, -130 dBm, > 6 SVs)

See also
https://www.u-blox.com/de/product/neo-m8-series

Internet

Most recent firmware and data sheet of the *HSx* box:
http://tellert.de/?product=hsx

Most recent device driver and installation guides for the USB connection cable *USBSER/B719K5:*
http://tellert.de/?product=usbser

Information about GPS receiver unit used by *HSx* box:
http://tellert.de/?product=hsx-gps

Information about Binder connectors:
http://tellert.de/?product=b719

Annex 1: Connection Plans

Figure 4 presents five different connection plans. Plan A is for the CAN connection of a HSx with the CAN2 connector of a data logger or a signal converter. Plan B is for the RS232 connection of a HSx with a data logger or signal converter. Plan C is for the RS232 connection of a DDD1 with a data logger or signal converter. Plan D is for the RS232 connection of a DDD1 with a HSx. Plan E is for connecting two DDD1 with one common GPS antenna. In this case, the GPS antenna must be connected to the DDD1 master. For plan A to D, the GPS receiver is turned on/off with the slider of the main device. From the two plans A and B, plan B is recommended, if the main device is a SICOLOG/SICO3/USBDL1 variant.

Plan F is a Y distributor cable for the concurrent connection of an external display (e. g. *ED4 RS232*) and a GPS receiver (via NMEA) to a data logger or signal converter. An additional cable "B" (= plan "B") is required for GPS receiver *HSx*.

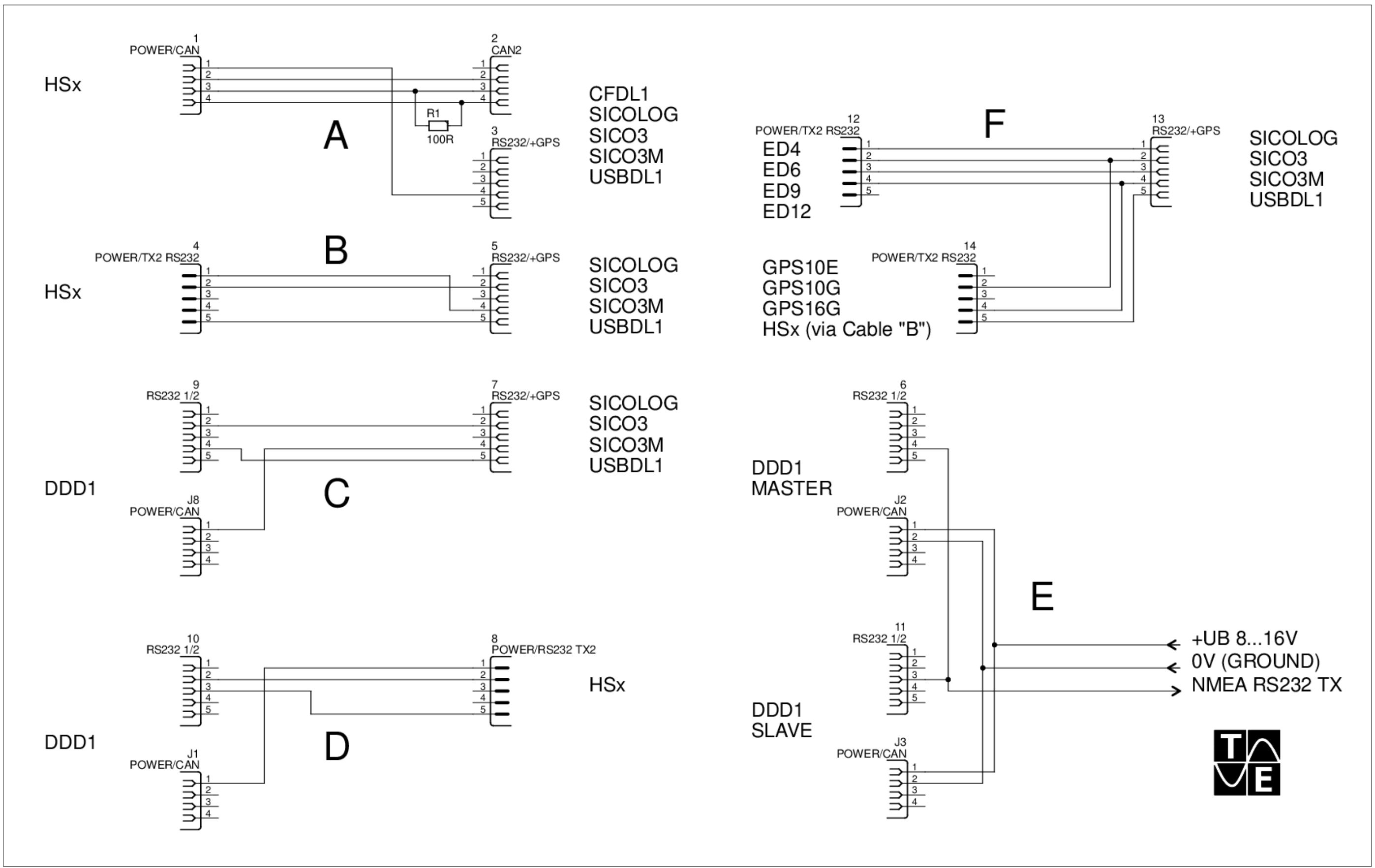

Figure 4: Connection plans.