

1 Controller board

1.1 The architecture

The heart of the controller boards is an Atmel 8-bit AVR micro controller ATmega644A running with a clock frequency of 20.000000 MHz. The board also contain two separate 8-bit analog-to-digital converters ADC 0820 CCN operating in high speed mode, i.e., not powered down between conversions. In this mode of operation, the converters are capable to provide a throughput of up to 500 ksp/s = 500.000 samples per second. A quad comparator TCL 374 activates the analog-to-digital conversion, if the input signal exceed a threshold of ± 0.417 Volt.

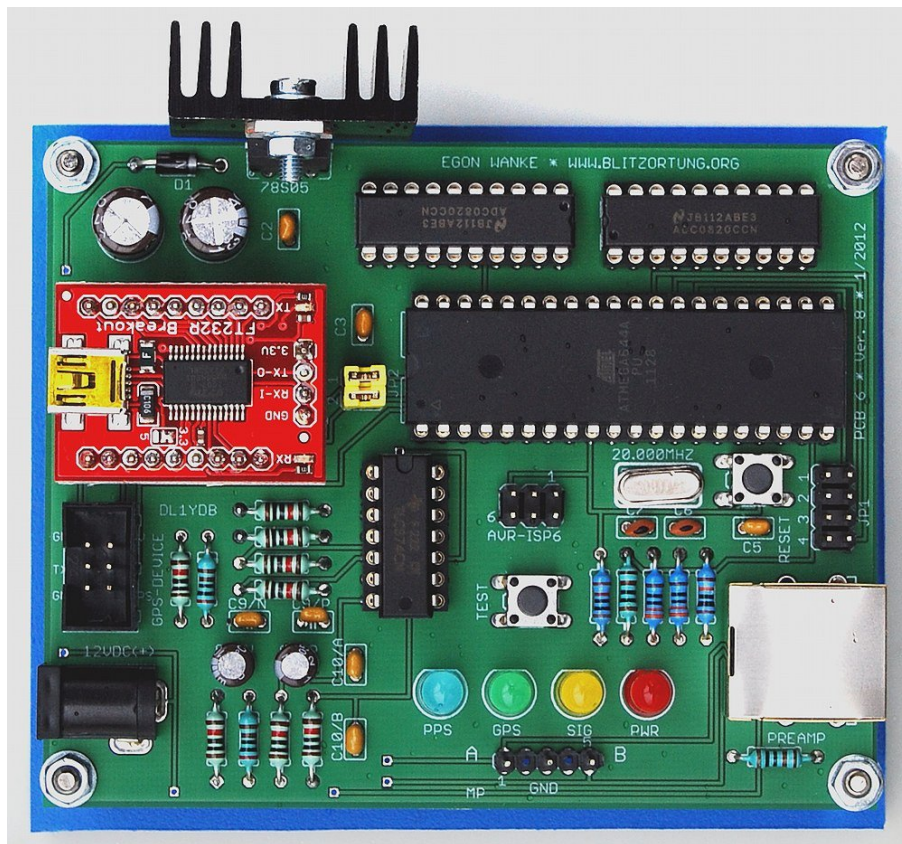


Figure 1: An assembled controller board PCB 6 Version 8usb

The micro-controller works as follows. An internal timer is initialized to run with clock frequency divided by 8 and will be triggered by the rising edge of the 1PPS signal from the GPS receiver. The counter difference between two 1PPS signals is approximately 2500000 units. One counter unit corresponds to 400 ns. If the signal from the receiver reaches the thresholds of ± 0.417 Volt, the controller captures the counter and starts the analog-to-

digital conversion. After that the controller takes 256 samples of every AD converter. This corresponds to a sampling duration of approximately $500\mu s$. Additionally, the controller permanently reads the GPRMC and GPGGA data sentences of the GPS receiver and stores the time, the geographic position, the altitude, and the number of used satellites. It outputs a data sentence for every second and for every recorded data sequence.






Resistor, metal 1%	R12	100 k Ω 
	R2, R3/N+P, R5, R6, R7/N+P, R8/N+P, R9	10 k Ω 
	R4/N+P	2 k Ω 
	R1	1 k Ω 
	R10, R11	330 Ω 
Capacitor, electrolytic	C1, C4	330 μF
	C8/N+P	4.7 μF
Capacitor, ceramic, pitch 2.5 mm	C2, C3, C5, C9/N+P	100 nF
	C10/A+B	(104)
	C6, C7	15 pF
rectifier diode	D1	1N4001
LED, standard	PWR LED	LED 5 mm (red)
	SIG LED	LED 5 mm (yellow)
	GPS LED	LED 5 mm (green)
	PPS LED	LED 5 mm (blue)
Quartz crystal	Q1	20.000000 MHz
Voltage regulator	IC1	$\mu 78S05$
Comparator	IC2	TCL 374
Analog-to-digital converter	IC3, IC4	ADC 0820 CCN
USB-to-serial breakout board	IC5	SparcFun BOB-00718
Micro controller	IC6	ATmega644A 20PU

Table 1: The electronic part list for the controller board PCB 6 Version 8usb

PCB 6 Version 8 uses an USB to serial Breakout Board from <http://www.sparcfun.com> with a FT232RL. It supports only GPS modules with 5 Volt power supply and a serial TTL interface. The PCB 6 Version 8usb board is designed to operate preferable with the EM-406A GPS module. It has additionally a 6-pin header for an AVR in-system program-

mer interface (ISP interface). This interface can be used to reprogram the controller.

1.2 Power supply

The amplifier and the controller board can be connected by a 1-to-1 Cat cable via the RJ45 jacks. We prefer a shielded Cat 5 cable. This connection also allows you to use the same power supply for both boards.

The DC jack can be used for separate power supply with positive polarization at the center. The voltage should not fall under 10 Volt and should not exceed 15 Volt. The normal operation is 12 Volt.

1.3 The LEDs



Figure 2: The LEDs of the controller board

In this section we describe the meaning of the LED of the controller board. This does not concern the LED attached the GPS module. When power supply is connected to the board, then the following will happen.

- The (red) PWR LED will light and the other three LEDs will blink four times one after the other. This just indicates that the controller is running.
- The (green) GPS LED starts blinking if the controller recognizes a GPRMC data sentence from the GPS. If the (green) GPS LED remains off, then in most cases the baud rate of the GPS differs from the baud rate of the controller. To find the right baud rate, change the setting of the baud rate jumper JP1 at PCB 6 Version 8usb and push the reset switch. If the GPS device is on track, that is, if the GPRMC data sentence contains status “A” and not status “V”, the green GPS LED will light permanently. This is usually already the case when the GPS device receives at least one satellite. If the green GPS LED remains blinking, you should move the GPS to a more adequate place on a window or on a place with a view to the sky.
- The (blue) 1PPS LED will blink every time the GPS provides a 1PPS signal. This will be every second. The (blue) 1PPS LED usually starts blinking immediately after the green GPS LED lights permanently.

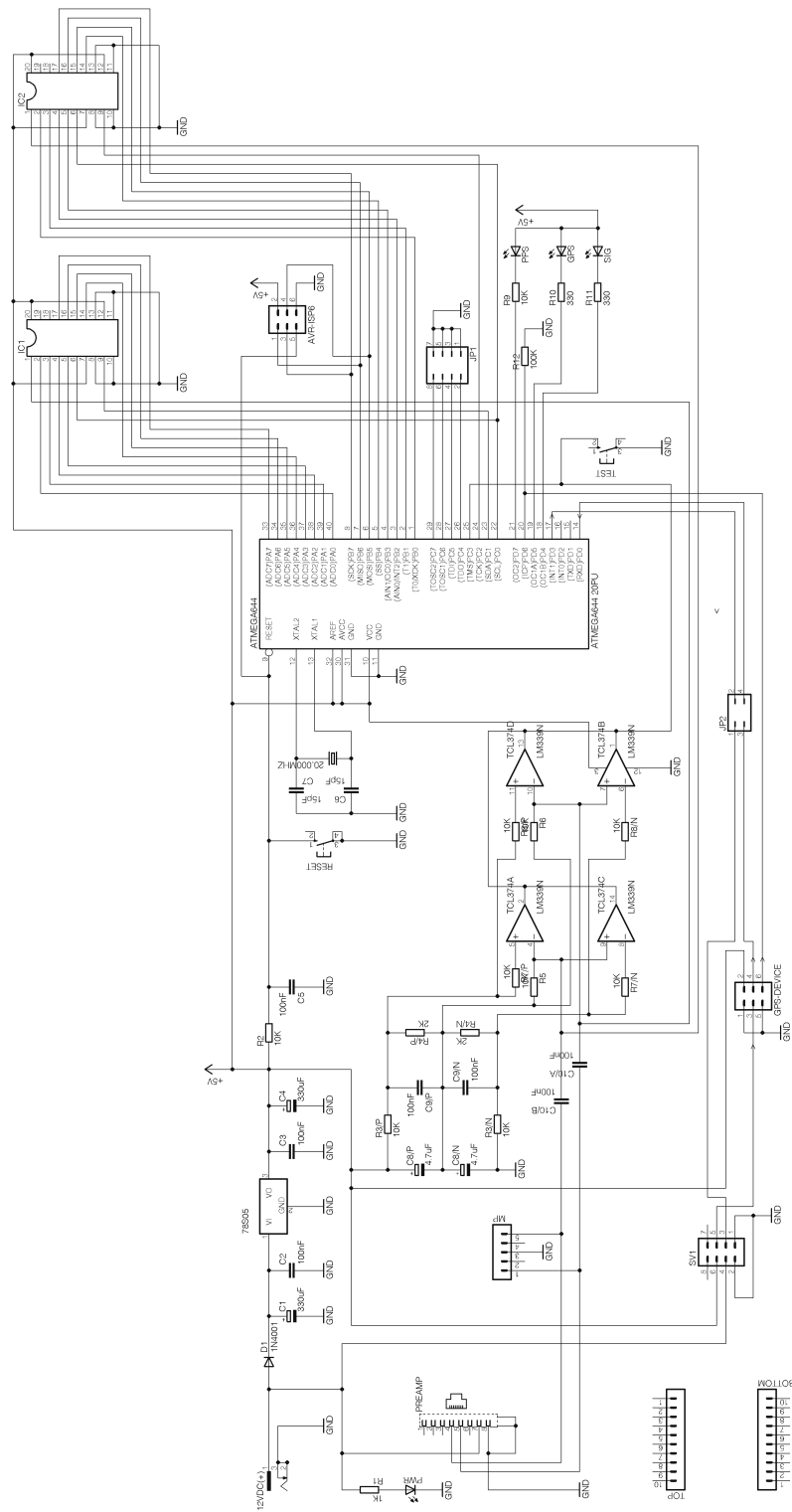


Figure 3: The circuit diagram of the controller board PCB 6 Version 8usb

- The (yellow) SIG LED will flash every time the controller outputs a data sentence containing strike signal information.

The LED series resistors R1, R0, R10, and R11 for the Version 8usb board need to be adjusted corresponding to the illuminating power of the used LEDs. For standard LEDs, the series resistor R1 for the red LED should be 1 k Ω , the series resistor R9 for the blue LED should be 10 k Ω , and the series resistors R10 and R11 for the yellow and green LED should be 330 Ω .

1.4 The measuring point



Figure 4: The Measuring Point MP1 of the controller boards Version 6 and Version 8usb

The measuring point MP1 provides at Pin 1 and Pin 5 the two signals from the amplifier. Channel A at Pin 1 and Channel B at Pin 5. Pin 3 of MP1 is connected to the ground of the board. These pins can be used to control the amplifier output with an oscilloscope or other measuring instruments. You should not use instruments with low impedance, because this could reduce the signal strength.

1.5 The jumper settings for PCB 6 Version 8usb

Jumper JP1 of PCB 6 Version 8usb serves two functions. First, it allows you to change the baud rate used by the GPS module between 4800, 9600, 19200, and 38400 baud, 8 bit, 1 stop bit, no parity, see Figure 5, and second, it allows you to change the baud rate of the serial interface of the controller between 115200, 230400, 250000, and 500000 baud, 8 bit, 1 stop bit, no parity, see Figure 6.

The GPS should always run with its default baud rate. The default baud rate of the EM-406A GPS module is 4800 baud. There is no need to change the baud rate for the GPS to other values. It is better the GPS module runs with a low baud rate (4800 baud) instead of a high baud rate (38400 baud). The other baud rate jumper positions are only implemented for the use with different GPS modules.

The baud rate of the serial connection to the PC should be changed to the highest possible value taht your PC and the tracker program supports. To change the baud rate, you have to execute the following procedure. Power off the board, disconnect the USB cable from your PC, set the right jumper on the board, power on the board, connect the

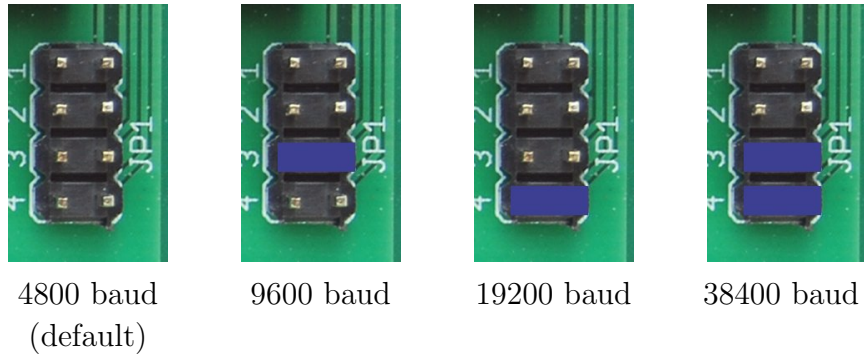


Figure 5: Setting of Jumper JP1 of PCB 6 Version 8usb

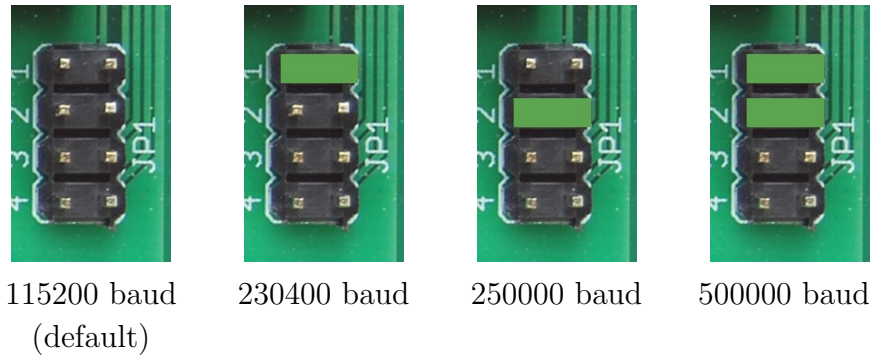


Figure 6: Setting for Jumper JP1 of PCB 6 Version 8usb

board with the PC (plug in the USB cable), start the tracker program, and select the new baud rate with your tracker program. The tracker for Windows currently does not support other baud rates than 115200 baud.

Jumper JP2 can be used to bypass the serial connection to/from the controller. The setting shown in Figure 7 to the left connects the output of the GPS device with the input of the controller and the output of the controller with the output of the board. This is the normal operation. The setting to the right separates the controller from the serial stream. It connects the output of the GPS device with the output of the board. This setting allows you to monitor the output of the GPS device at the serial interface of the board.

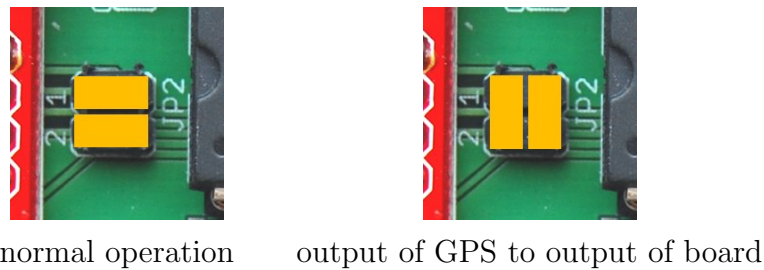


Figure 7: Setting for Jumper JP2 of PCB 6 Version 8usb

1.6 Output of the controller boards

The output of the board provides data formatted NMEA 0183, Version 2.0. There are three types of sentences starting with \$BS, \$BD, and \$BM, see Table 2 and 3. A \$S sentence is output every second, a \$L sentence is output every time one of the inputs exceeds the threshold voltages of the comparators.

```
$S,B9D51B,A,121152,260611,5111.9504,N,00647.0883,E,40.70,07,29a*72<CR><LF>
|
| | | | | | | | |
| | | | | | | | | Checksum
| | | | | | | | |
| | | | | | | | | Firmware Version
| | | | | | | | |
| | | | | | | | | Number of satellites in use
| | | | | | | | |
| | | | | | | | | Altitude, meter above/below mean sea level
| | | | | | | | |
| | | | | | | | | Longitude hemisphere, E=east or W=west
| | | | | | | | |
| | | | | | | | | Longitude, 7 deg 39.3538'
| | | | | | | | |
| | | | | | | | | Latitude hemisphere, N=north or S=south
| | | | | | | | |
| | | | | | | | | Latitude, 51 deg 11.953
| | | | | | | | |
| | | | | | | | | Date, 13.03.2011
| | | | | | | | |
| | | | | | | | | Time, 12:11:52 UTC
| | | | | | | | |
| | | | | | | | | Status, A=active or V=invalid
|
Counter, 24 bit hexadecimal
```

Table 2: Format of the \$S sentence. The information of the Time/Date field refers to the point in time of the preceding 1PPS signal. That is, the time stamp is always 1 second slow.

1.7 The GPS connector of PCB 6 Version 8usb

The pin assignment of the header of PCB 6 Version 8usb is shown in Table 4.

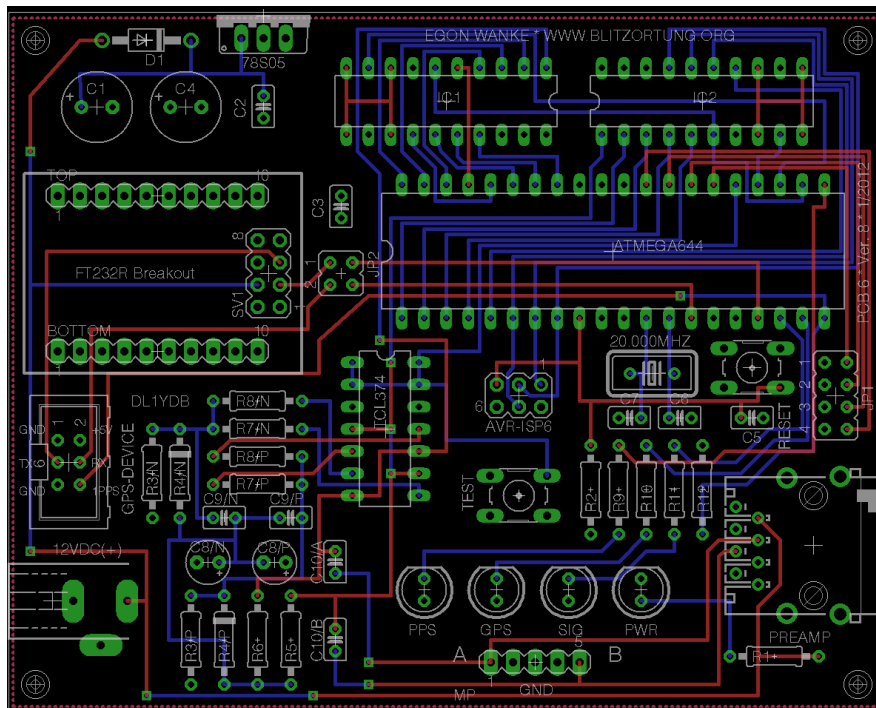


Figure 8: The layout of the controller board PCB 6 Version 8usb

2 Data upload

The data upload is carried out by a **tracker program**. It reads and processes the data of the controller board and sends the resulting lightning data to our computing server. We provide two types of tracker programs, one for computers running a Linux operating system and one for computers running a Windows operating system. The official tracker program for Linux is written by Egon Wanke. We only provide the C++ source code of the Linux tracker program. You have to compile the source code using any C++ compiler for your Linux system. The official tracker program for Windows is written by Edmund Korffmann. It consists of only one small executable file. You can download both tracker programs from the "Miscellaneous" page of the "Services" menu of Blitzortung.org. However, you can also use the other tracker programs written by some of the participants. Please do not write and use own written tracker programs without to get in contact with us.

2.1 The official tracker program for Windows

In this section, we briefly explain how to work with the tracker program for Windows. The current Version for the controller board PCB 6 Version 8usb (at the time this text has been written) is "WT 6.00". The program consists of one small (less than 250 K) executable file named "serial_tracker". You can store the tracker program in any directory, also on your desktop. It should run at all Windows systems. If you are running an extraordinary Windows system, please get in contact with us. The tracker program stores the used settings in a configuration file called "Tracker.prefs" placed in the same directory.

First, connect the GPS device to the controller board and the controller board to your computer. Disconnect the amplifier. We recommend to set the jumper of the controller board to 4800 baud for the GPS and 115200 baud for the serial connection to the PC. Then power on the controller board and start the tracker program. Select the serial device, the baud rate, and the GPS type, as shown in Figure 9, and initialize the GPS device. If you are using a Garmin GPS device then the initialization is not carried out until the next power on. In this case, you have to disconnected and then again to connect the power supply. Now the green LED should start blinking, and after a while it should continuously light. If the green LED blinks, the controller board receives GPRMC sentences with status 'V' (= invalid), if it lights permanently, it receives GPRMC sentences with status 'A' (= active). If the green LED is off, either the baud rate of the GPS does not match the baud rate of the controller board, or something else fails. In this case, you can use the port monitor to control the serial connection with the controller board, see Figure 11. If you push the reset button of the controller board, then the micro-controller outputs its firmware version. If the firmware version text string is not listed at the port monitor, then the baud rate of the controller board does not match the baud rate selected at you PC for the serial device.

You can turn the yellow jumpers at the controller board by 90 degrees to see the output of the GPS device at the port monitor. If the green LED is blinking and does not turn into a permanent light, then move the GPS device outside, or at least to a window side.

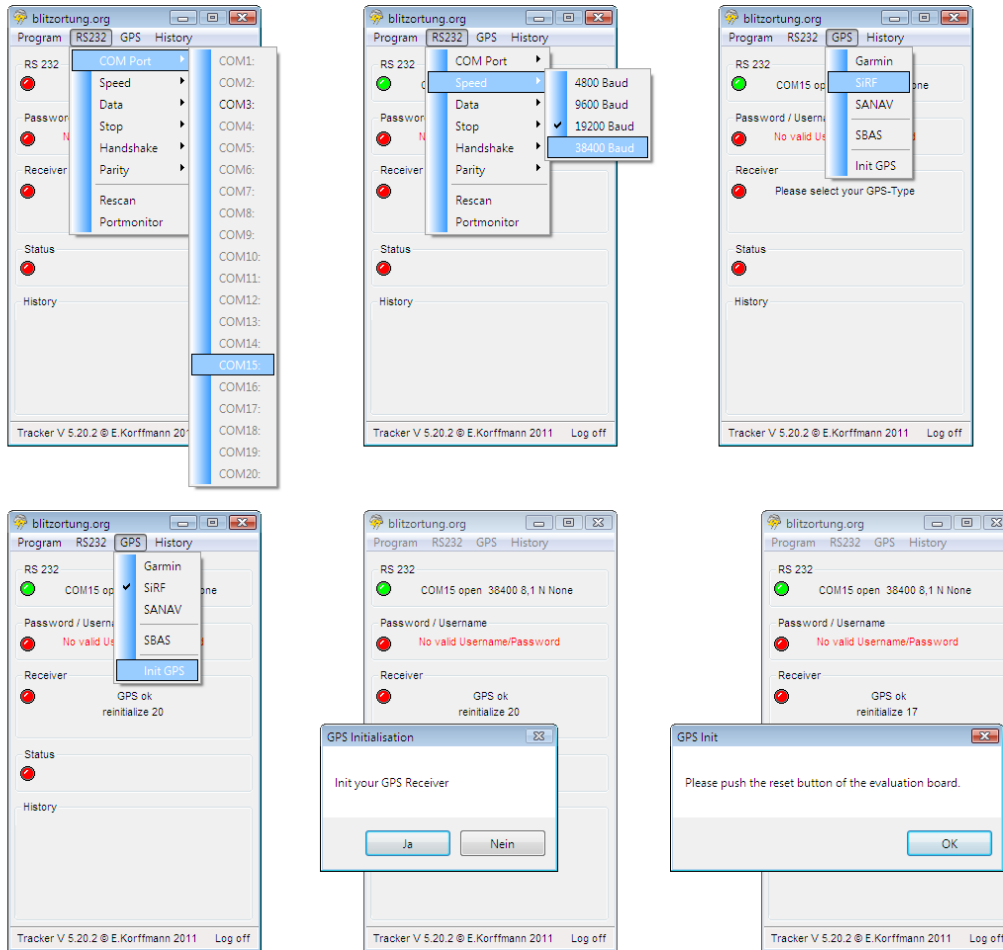


Figure 9: The initialization of the serial connection and the GPS device

Next you should insert your username and password. The username is the one you got from blitzortung.org. The password is the one you have chosen by yourself. The tracker program will not accept the password you initially got from Blitzortung.org. You have to select a new own password.

Activating the "Auto" flag will cause the tracker to start up automatically after the PC will restart. If the "Minimize" flag is set the tracker program window will disappear from the desktop and move to you tool bar. The "Logfile" flag activates log file output, and the "Adj. System Time" option allows to synchronize the local clock by the GPS time. The "Region" menu is used to distinguish between different computing servers for different continents. At the time this document is written, there is only one region, Region 1, for

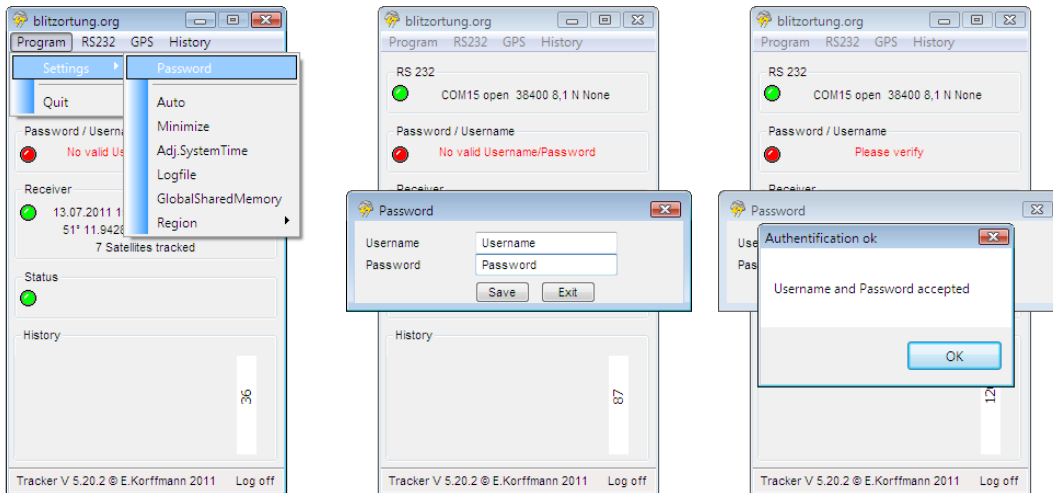


Figure 10: Inserting the password and user name

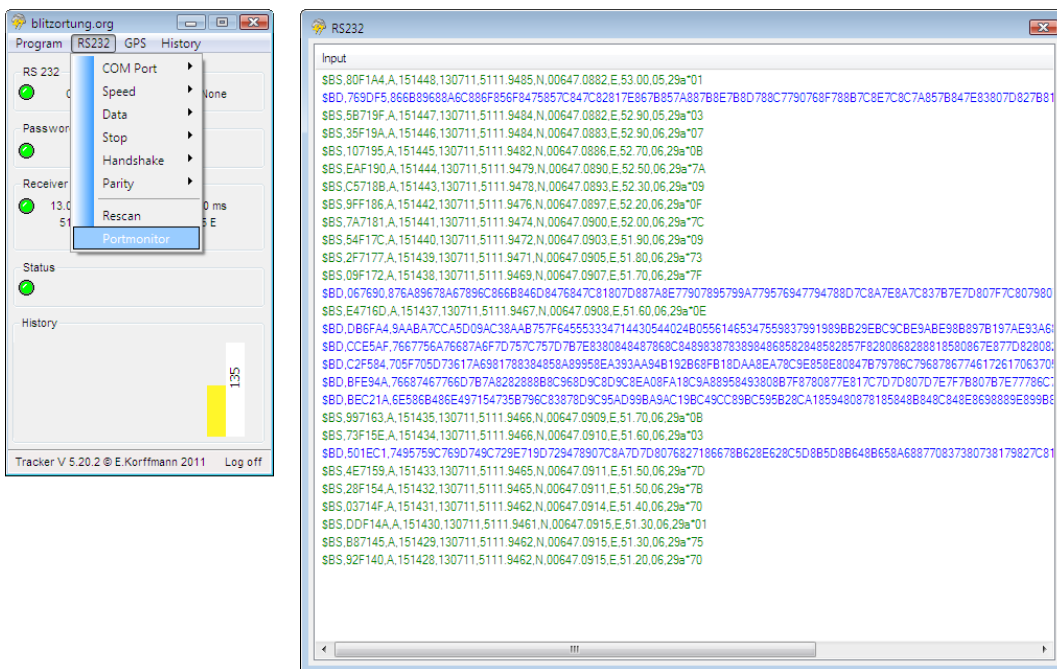


Figure 11: The port monitor

Europe. Different setting for the History window can also be chosen, see Figure 12.

2.2 The official tracker program for Linux

The source code of the tracker program for Linux can be downloaded from the "Miscellaneous" page of the "Services" menu of Blitzortung.org. The file tracker_Linux.c

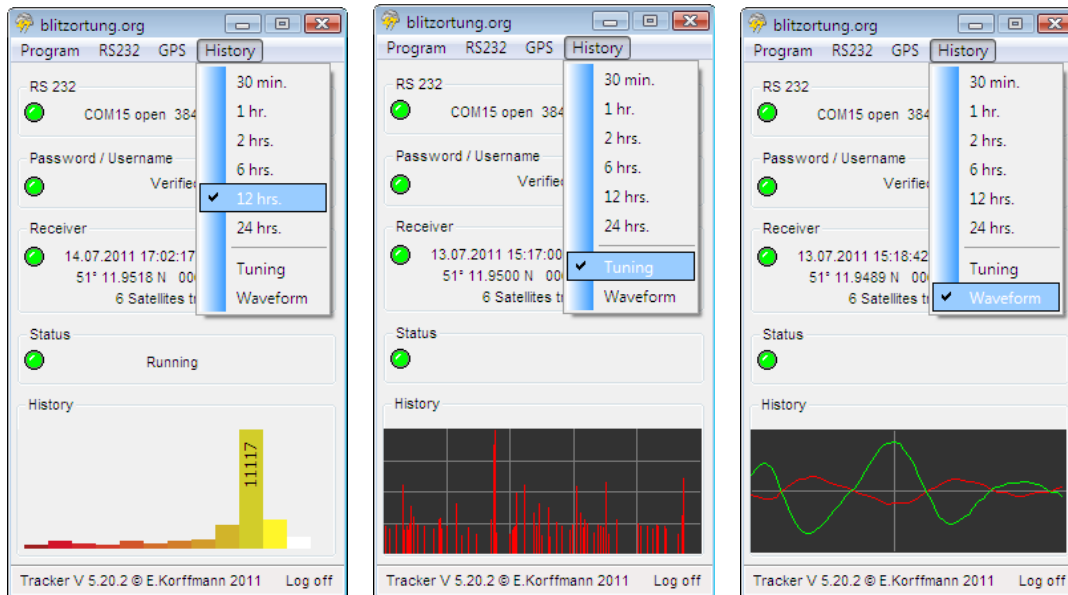


Figure 12: Different settings for the history window

should be compiled by `g++ -Wall -lm -o tracker_Linux tracker_Linux.c` to the executable `tracker_Linux`. A short description of all options can be listed by starting the tracker program with option `"-h"`, see the following screen dump.

```
> g++ -Wall -lm -o tracker_Linux tracker_Linux.c
> ./tracker_Linux -h
./tracker_Linux: [-h] [-L] [-ll file] [-lo file] [-ls file] [-vl] [-vo] [-vs] [-vi] [-e serial_device] [-s]
gps_type baud_rate serial_device username password
gps_type      : gps type (SANAV, Garmin, or SiRF ('-' for no initialization))
baud_rate     : baud rate (4800, 9600, 19200, or 38400)
serial_device : serial device (example: /dev/ttyS0)
username      : username (example: PeterPim)
password      : password (example: s36r67hi)
-h            : print this help text
               alternative: --help
-L            : write log messages to the system message logger
               alternative: --syslog
-ll file     : write log messages to file
               alternative: --log_log file
-lo file     : write board output to file
               alternative: --log_output file
-ls file     : write sent information to file
               alternative: --log_sent file
-vl          : verbose mode, write log messages to stdout
               alternative: --verbose_log
-vo          : verbose mode, write board output to stdout
               alternative: --verbose_output
-vs          : verbose mode, write sent information to stdout
               alternative: --verbose_sent
-vi          : verbose mode, write system information to stdout
               alternative: --verbose_info
-e serial_device : serial device for input echo
```

```

                alternative: --echo serial_device
-s             : activate SBAS (WAAS/EGNOS/MSAS) support
                alternative: --SBAS

```

If the tracker is started with option `-vl`, `-vo`, and `-vi` for SiRF GPS devices using 38400 baud, it will create the following output. We have omitted some line from the complete output indicated by dots "...".

```

> ./tracker_Linux -vl -vo -vi SiRF 38400 /dev/ttyUSB0 PeterPim s36r67hi
2011-07-15 19:00:46, PID: 11524, tracker started
2011-07-15 19:00:46, PID: 11524, $PSRF103,00,00,01,01*25
$PSRF103,01,00,00,01*25
$PSRF103,02,00,00,01*26
$PSRF103,03,00,00,01*27
$PSRF103,04,00,01,01*21
$PSRF103,05,00,00,01*21
$PSRF103,06,00,00,01*22
$PSRF103,08,00,00,01*2C
$PSRF100,1,38400,8,1,0*3D
$PSRF151,00*0E
2011-07-15 19:00:46, PID: 11524, initialize GPS with SiRF, 38400 baud, using 38400 baud, please wait!
2011-07-15 19:00:49, PID: 11524, initialize GPS with SiRF, 38400 baud, using 19200 baud, please wait!
2011-07-15 19:00:51, PID: 11524, initialize GPS with SiRF, 38400 baud, using 9600 baud, please wait!
2011-07-15 19:00:54, PID: 11524, initialize GPS with SiRF, 38400 baud, using 4800 baud, please wait!
2011-07-15 19:00:57, PID: 11524, Ready!
$BS,B85DD4,A,192315,150711,5111.9575,N,00647.0819,E,39.20,06,29a*77
$BS,DDDDDC,A,192316,150711,5111.9574,N,00647.0820,E,39.40,06,29a*05
122880 lat: +0.000711, lon: +0.000094, alt: +0.0, acc: -19000000000 nsec, sat: 6
2011-07-15 19:00:58, PID: 11524, GPS status changed from '-' to 'A'
$BS,035DE3,A,192317,150711,5111.9573,N,00647.0821,E,40.40,06,29a*0F
245761 lat: +0.002133, lon: +0.000283, alt: +0.0, acc: -8999997966 nsec, sat: 6
2011-07-15 19:00:59, PID: 11524, GPS seconds running, 16 17
$BS,28DDEB,A,192318,150711,5111.9568,N,00647.0821,E,42.60,06,29a*03
368641 lat: +0.004266, lon: +0.000565, alt: +0.0, acc: -5666667571 nsec, sat: 6
...
$BS,A65E6B,A,192335,150711,5111.9545,N,00647.0805,E,63.40,07,29a*7B
2457608 lat: +51.199256, lon: +6.784684, alt: +54.2, acc: +224 nsec, sat: 7
2011-07-15 19:01:17, PID: 11524, Position fixed, lat: +51.199256, lon: +6.784684, alt: +54.2
2011-07-15 19:01:17, PID: 11524, 1PPS signal accuracy ok, counter: 80DE64 A65E6B, +224 nsec
$BS,CBDE73,A,192336,150711,5111.9545,N,00647.0805,E,63.40,07,29a*0F
2457608 lat: +51.199256, lon: +6.784684, alt: +54.2, acc: -183 nsec, sat: 7
$BS,F15E7A,A,192337,150711,5111.9544,N,00647.0806,E,63.30,07,29a*7E
2457608 lat: +51.199256, lon: +6.784684, alt: +54.2, acc: +224 nsec, sat: 7
$BS,16DE82,A,192338,150711,5111.9544,N,00647.0807,E,63.30,07,29a*0D
2457608 lat: +51.199256, lon: +6.784684, alt: +54.2, acc: -183 nsec, sat: 7
$BD,1E213B,6B806D82708275807B7F817F848185818480827E827F7C7E797F777E777C797C7E8080827F ... 817F*0F
$BS,3C5E89,A,192339,150711,5111.9545,N,00647.0810,E,62.70,07,29a*03
2457608 lat: +51.199256, lon: +6.784684, alt: +54.2, acc: +203 nsec, sat: 7
...

```

It is recommended to write a start/stop script for directory `/etc/init.d/` and/or `/etc/rc2.d`, such that the tracker will start automatically after a reboot. An example of such a start script for Debian and Ubuntu Linux distributions can also be found on the "Miscellaneous" page.

2.3 The interference mode

The **interference mode** is used to reduce the amount of improper data send to the server. The tracker program enters the interference mode if it receives for more than 10 seconds every second at least one lightning data. If this happens, it is assumed that the major part of the received signals are not lightning data but interferences. During the interference mode, no further data are send to our server. The tracker program leaves the interference mode immediately after it receives no data for at least one second.

3 Prices and how to get the material

We only offer the two PCBs and the programmed ATmega644 micro-controller. We do not offer completely assembled kits. You have need to gather all the necessary parts by yourself, but we will try to help you to find a vendor where you can buy all these parts in your country. In exceptional cases, we deliver complete kits (not assembled) if the parts are very difficult to get in certain countries. In this case, we sell everything at cost prices without profit-making intentions. We only sell parts to persons who promise to take part to the network. You will receive our bank account information and PayPal address on request.

To get an overview of the costs for assembling such a system, we state here some examples of prices. These are approximate prices of traders in Germany. Clearly, the prices will differ from country to country, but a rough orientation seems to be always interesting for an estimation of the total costs. Tables 5 and Table 6 show the prices for the parts of the complete kits for PCB 5 Version 7 and PCB 6 Version 8usb in Germany at the time this document was written.

The prices for shipping the kits from Germany are

7,00	€	with DHL (max 5 kg)	within Germany
17,00	€	with DHL (max 5 kg)	to European countries (European Union),
30,00	€	with DHL (max 5 kg)	to European countries (not EU)
35,00	€	with DHL (max 5 kg)	to USA/Canada, and
40,00	€	with DHL (max 5 kg)	to all over the world.

Additionally you need a GPS device providing a 1PPS output, for example, the EM-406A module for approximately 40 €, and a VLF antenna, for example, a ferrite rod or a loop antenna. Suitable ferrite rod antennas can be obtained from <http://www.sfericsempfang.de>, order number SKS 200 BL (approximately 22 €each).

Please remember: **Blitzortung.org** is a community of volunteers with noncommercial interests. We spend our free time to buy the necessary parts here in Germany, pack them into a parcel, and ship it to you. We do all this just as a favor, there is no extra charge. Since we are no salesmen, we do not write invoices for the material and service (only on occasional exception, if the users will try to get back the appropriate amount through official channels).

If you want to build your own station, first write an email to the author of this document.

Part	approximate Price
Semiconductors	
4× AD8055	4× 1,60 €
1× 1N4001, rectifier diode	1× 0,05 €
1× LED, 5 mm, red	1× 0,10 €
∑	6,55 €
Capacities	
3× 330 μF, 16 V, electrolytic 8×11 mm, pitch 3.5 mm	3× 0,10 €
1× 100 μF, 16 V, electrolytic 5×11 mm, pitch 2.5 mm	1× 0,10 €
13× 100 nF, ceramic, pitch 2.5 mm	13× 0,10 €
6× 22 nF, ceramic, pitch 2.5 mm	6× 0,10 €
8× 100 pF, ceramic, pitch 2.5 mm	8× 0,10 €
4× 47 pF, ceramic, pitch 2.5 mm	4× 0,10 €
∑	3,50 €
Inductors	
3× 330 μH, ferrite, pitch 5 mm	3× 0,50 €
∑	1,50 €
Resistors	
2× 1 MΩ, metal 1%	2× 0,10 €
12× 100 kΩ, metal 1%	12× 0,10 €
4× 47 kΩ, metal 1%	4× 0,10 €
2× 10 kΩ, metal 1%	2× 0,10 €
2× 6.04 kΩ, metal 1%	2× 0,10 €
2× 2.37 kΩ, metal 1%	2× 0,10 €
9× 1 kΩ, metal 1%	9× 0,10 €
4× 82 Ω, metal 1%	4× 0,10 €
4× 47 Ω, metal 1%	4× 0,10 €
∑	4,10 €
Further material	
1× PCB 5 Version 7	1× 10,00 €
1× RJ45 jack, 8 ways, shielded	1× 0,60 €
1× DC jack, PCB, 2.1 mm	1× 0,20 €
1× Jack socket, PCB, 3,5 mm	1× 0,25 €
2× Terminal block, PCB, 3 way, pitch 5 mm	2× 0,30 €
4× IC socket, 8 ways	4× 0,20 €
1× Pin header, 14×40 pins	1× 0,25 €
20× Jumper	20× 0,10 €
1× Power Supply, 12 V, stabilized	1× 6,00 €
∑	20,70 €
∑	<u>36,35 €</u>

Table 5: Approximate prices of the parts for the amplifier kit PCB 5 Version 7 including a power supply

Part	approximate Price
Semiconductors	
1× ATmega644A-20PU	1× 6,50 €
1× Breakout Board for FT232RL USB to Serial	1× 12,00 €
2× ADC 0820 CCN	2× 3,00 €
1× TLC 374	1× 0,60 €
1× 78S05	1× 0,40 €
1× 1N4001, rectifier diode	1× 0,05 €
1× LED, 5 mm, red	1× 0,10 €
1× LED, 5 mm, yellow	1× 0,10 €
1× LED, 5 mm, green	1× 0,10 €
1× LED, 5 mm, blue	1× 0,30 €
Σ	26,15 €
Capacities	
2× 330 μ F, 16 V, electrolytic 8×11 mm, pitch 3.5 mm	2× 0,10 €
2× 4.7 μ F, 100 V, electrolytic 5×11 mm, pitch 2.5 mm	2× 0,10 €
7× 100 nF, ceramic, pitch 2.5 mm	7× 0,10 €
2× 15 pF, ceramic, pitch 2.5 mm	2× 0,10 €
Σ	1,30 €
Resistors	
1× 100 k Ω , metal 1%	1× 0,10 €
10× 10 k Ω , metal 1%	10× 0,10 €
2× 2 k Ω , metal 1%	2× 0,10 €
1× 1 k Ω , metal 1%	1× 0,10 €
2× 330 Ω , metal 1%	2× 0,10 €
Σ	1,60 €
Further material	
1× PCB 6 Version 8usb	1× 10,00 €
1× Crystal, 20,000000 MHz	1× 0,30 €
1× RJ45 jack, 8 ways, shielded	1× 0,60 €
1× DC jack, PCB, 2.1 mm	1× 0,20 €
1× Straight Header Connector jack, 6 ways	1× 0,25 €
5× Header Connector plug, 6 ways	5× 0,25 €
1× Pin header, 1×40 pins	1× 0,25 €
6× Jumper	6× 0,10 €
2× Mini switch	2× 0,15 €
1× Cooling device, TO220	1× 0,50 €
1× IC socket, 40 ways	1× 0,65 €
2× IC socket, 20 ways	2× 0,50 €
1× IC socket, 14 ways	1× 0,30 €
1× Connection cable, A-/Mini-B-USB	1× 2,00 €
1× Network cable, RJ45/RJ45, 10 m, CAT5	1× 3,00 €
1× 1 m ribbon cable for shielding ferrite rod antennas	1× 2,00 €
Σ	23,20 €
Σ	52,25 €

Table 6: Approximate prices of the parts for the controller board kit PCB 6 Version 8usb including connection cables