Blitzortung.org

A World-Wide Low-Cost Community-Based Time-of-Arrival Lightning Detection and Lightning Location Network

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This document will continually change due to further developments and improvements. Please send your remarks to mailto:blitzortung@gmx.org. Most of the receiving stations are currently operating in Europe, but we are emphatically interested to extend our activities to other continents. Please contact us, if you are interested to start the activity in you region.

Blitzortung.org is a world-wide non-commercial low-cost community-based Time-of-Arrival lightning detection and lightning location network. The system is made for private and entertainment purposes. The domain Blitzortung.org is not an official information service for lightning data. A commercial use of data from Blitzortung.org is strongly prohibited, even by the users that send data to our server.

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Contents

1   Lightning detection hardware

The hardware of our the lightning detection system consists of three components.

- Antenna System

  The VLF-signals are received by wide-band H-Field or E-Field antennas

- Amplifier

  A wide-band VLF-amplifier amplifies the antenna signal such that it can be further processed and analyzed.

- Controller

  The controller digitize the signals and send them together with the reception time and reception location to our server.

  Figure 1 shows a complete starter kit.

1.1   Antennas

(will be inserted later)
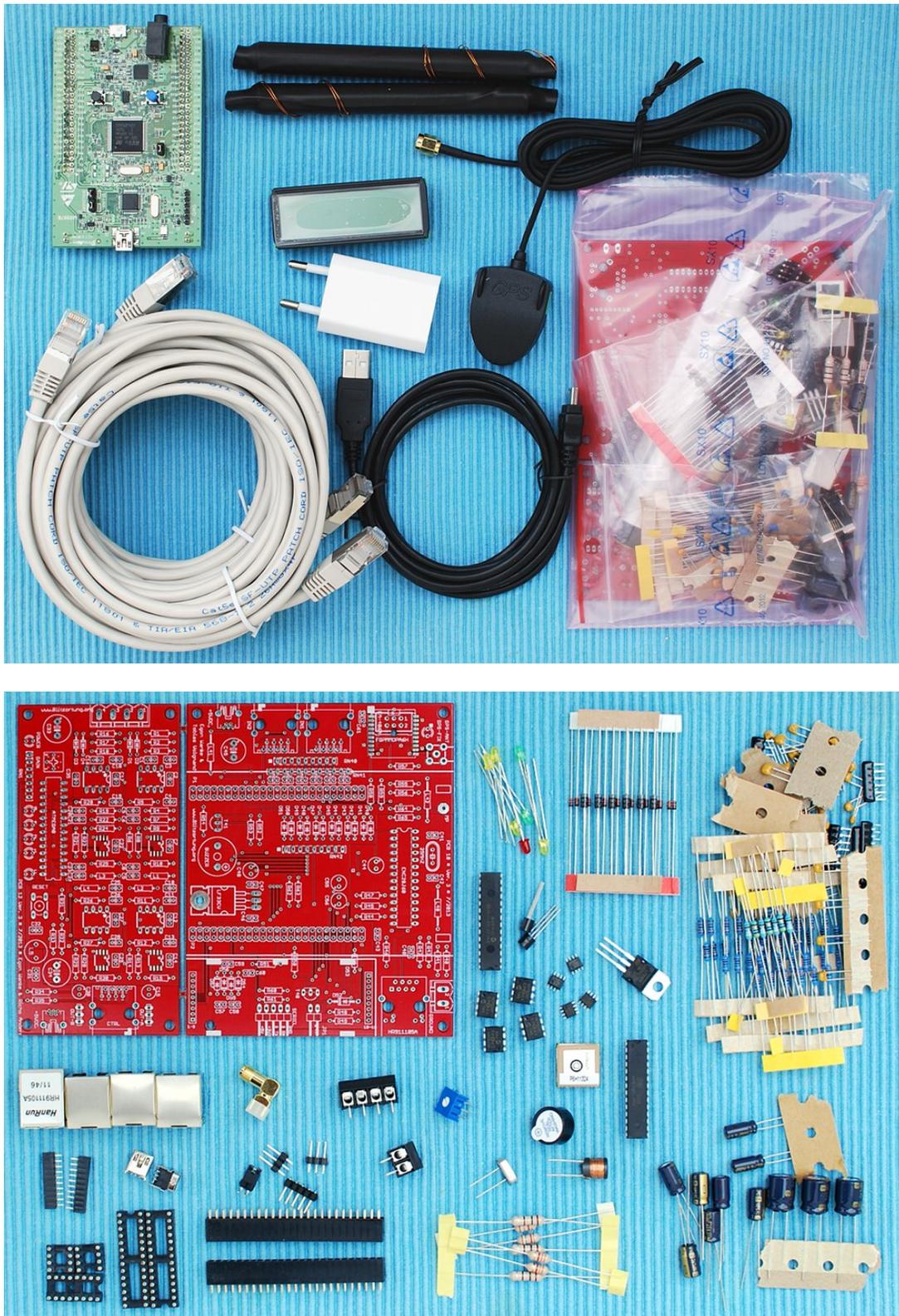
Figure 1:   A complete starter kit

1.2   Amplifiers

Every amplifier has its own specific signal characteristic depending on the type of the low-pass, the type of the high-pass filter, the type of the used op-amps and so on. The different types of the circuits and components can cause different signal forms and different time delays. This is the main reason why we strictly recommend that all users should exclusively use the same amplifier circuits, in particular, one of our recommended amplifier circuits. Wrong time stamps can considerably confuse our calculations. Finding the reason for false calculations can be very time consuming.

We offer several different amplifiers for different antenna types. Our standard amplifier for magnetic field antennas (H-field antennas) is Amplifier 12 Version 3. These are for example loop antennas or ferrite rod antennas An amplifier for electric field antennas (E-field antennas) will probably be introduced in the fall of 2013. We will modify the amplifier circuits from time to time to improve its quality for our special application and to reduce the price.

1.2.1   Amplifier 12 Version 3

Amplifier 12 Version 3 should be used for all magnetic loop antennas and all ferrite rod antennas. It uses four single supply 5 Volt rail-to-rail op-amp ICs for each channel. The inputs of the amplifier are terminated by damping resistors of 2.2kΩ. This leads to a more realistic current measurement for loop antennas and will reduce self resonances. For larger loop antennas, the damping resistor can be lowered to 100Ω- 300Ωin parallel to the antenna. A coax cable antenna can be terminated by 75Ω.

The first and third stage of the amplifier are realized by programmable gain amplifiers (PGAs) MCP6S91 from Microchip. The gain of these amplifiers is controlled by a serial peripheral interface (SPI) and can be adjusted between 1 and 32 for each MCP6S91. The second stage uses the dual op-amp MCP6292 from Microchip. The two operational amplifiers of this IC realize a Besssel high-pass filter with a cut-off frequency of approximately 1kHz. This filter is realized by two active Sallen-Key filter circuits. The second operational amplifier of the MCP6292 additionally increases the gain by a factor of 4. After this stage a Besssel low-pass filter with a cut off frequency of approximately 50kHz is placed. This filter is realized by a passive low-pass filter chain of order five. The last stage is realized by the output driver amplifier LMH6642 from Texas Instruments. This stage additionally increases the gain by an factor of 10. The maximal overall gain of the amplifier is about 76dB. The maximal output current is 75 mA.

The block diagram, circuit diagram, printed circuit board, and an assembled circuit board of Amplifier 12 Version 3 are shown in Figure 2, 3, 4, and 5, respectively.

1.2.1.1   Electronic parts   The electronic parts necessary for Amplifier 12 Version 3 are listed in Table 1. The additional necessary mechanical parts can be found in the complete part list, see table **??**.

operational amplifiers	IC1, IC3, IC5, IC7	MCP6S91 DIP8
	IC2, IC6	MCP6292 SMD SOI8
	IC4, IC8	LMH6642 SMD SOI8
LEDs	Power LED	LED 3mm (red)
	Control LED	LED 3mm (green)
	Gain LEDs 1,2,4,8	LED 3mm (yellow)
Diodes	D1, D2, D3, D4	1N4148
Resistors, metal 1%, 0207	R3, R13, R18, R28	100kΩ
	R6, R21	68kΩ
	R5, R7, R12, R20, R22, R27	22kΩ
	R2, R4, R14, R17, R19, R29, R31	10kΩ
	R8, R23	6.8kΩ
	R1, R9, R16, R24, R32, R33	2.2kΩ
	R10, R11, R25, R26	1kΩ
	R34, R35	330Ω
	R15, R30	47Ω
Resistor network, star, 6-1	RN1	1kΩA102
Potentiometer	P1	50kΩ
Capacitors, electrolytic, 5mm	C33, C34	470 μF
2mm	C15, C30	2.2 μF
Capacitor, ceramic, 2.54mm	C1, C2, C7, C11, C12, C13, C14, C16, C17, C22, C26, C27, C28, C29, C31, C32, C35	100 nF (104)
	C3, C18	22 nF (223)
	C4, C6, C19, C21	10 nF (103)
	C10, C25	6.8 nF (682)
	C5, C20	4.7 nF (472)
	C9, C24	2.2 nF (222)
	C8, C23	470 pF (471)
Inductors, ferrite, 5mm	L5	470/330 μH
Inductors, SMCC	L2, L4	3.3mH
SMCC	L1, L3	1.5mH

Table 1: The list of electronic parts for Amplifier 12 Version 3

1.2.1.2 Connecting an Antenna   The antenna is connected to the terminal block. If you are using ferrite rod antennas with varnished wires, you should solder the stripped wires to bigger copper wires that can be grasped by the terminals screws.

1.2.1.3 Gain Control   The serial peripheral interface (SPI) for setting the gain of the PGAs is controlled by the Atmel ATmega8 micro-controller. The gain can be adjusted either manually by a potentiometer or automatically by the controller board. It is a digital gain control in both cases. If the green LED named C is on, the gain is adjusted by the controller, if it is off, the gain is adjusted manually. The manual gain control operates as follows. A potentiometer is used for setting a variable voltage between 0 and 5 Volt measured by one of the A/D converters of the ATmega8 micro-controller. It determines from the adjusted voltage the corresponding digital gain values and send them to the PGAs via the serial peripheral

interface. In this case, the gain can be adjusted in 12 steps displayed by the yellow LED gain index as shown in Table 2.

LED 8	LED 4	LED 2	LED 1	first MCP6S91	second MCP6S91	gain factor
○	○	○	○	1	1	1
○	○	○	●	2	1	2
○	○	●	○	2	2	4
○	○	●	●	4	2	8
○	●	○	○	4	4	16
○	●	○	●	8	4	32
○	●	●	○	8	8	64
○	●	●	●	16	8	128
●	○	○	○	16	16	256
●	○	○	●	32	16	512
●	○	●	○	32	32	1024

Table 2: Gain index of Amplifier 12 Version 13

1.2.1.4   Connecting the controller   The RJ45 modular connector is used to connect the amplifier to the controller board. You should use a shielded one-to-one CAT 5e network cable. The length of the cable can be up to 30 meters. This allows to place the amplifier near the antennas far away from noisy environments.

1.2.1.5   Output test pins   The output test pins can be used to monitor the output of the amplifier. This is useful if you want to connect an oscilloscope or a sound card to analyze the VLF output without to disconnect the amplifier from the controller board.

1.2.1.6   First hardware check   For the first hardware check, do not connect the controller. After connecting a 5V USB power supply, the red power indicator LED should glow and the four yellow LEDs of the gain index should start flashing four times. The green LED should be off. A few seconds later the four yellow LEDs should display the adjusted gain. If the potentiometer is turned then the new gain value should be displayed, see also Table 2.

The green LED is only on if the amplifier is controlled by the controller board. In this case the yellow LEDs have no meaning. A manual gain adjustment is not possible if the gain is controlled by the controller.
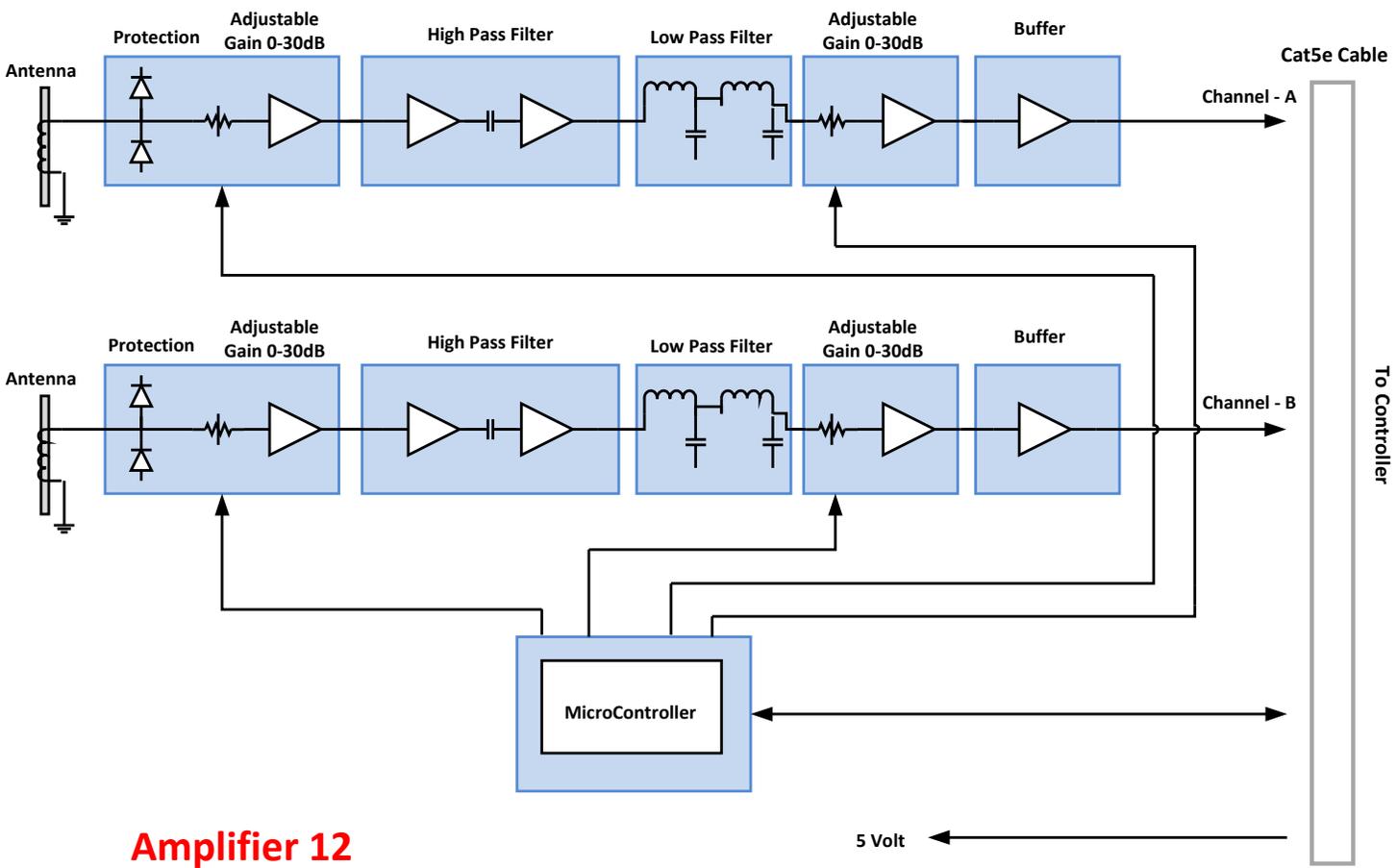
Figure 2: Block diagram of Controller Number 10 Version 3
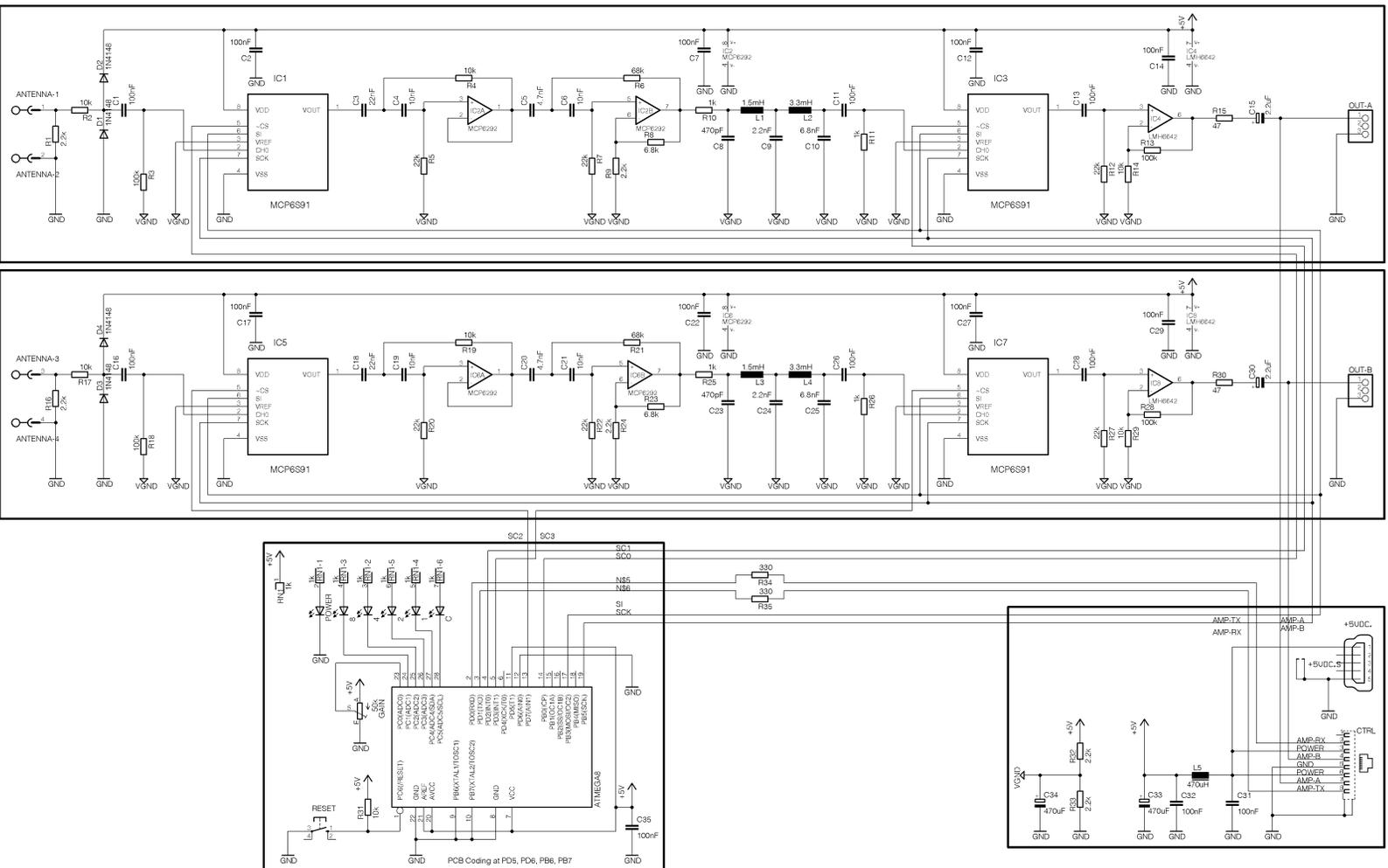
Figure 3: The complete circuit diagram of Amplifier 12 Version 3
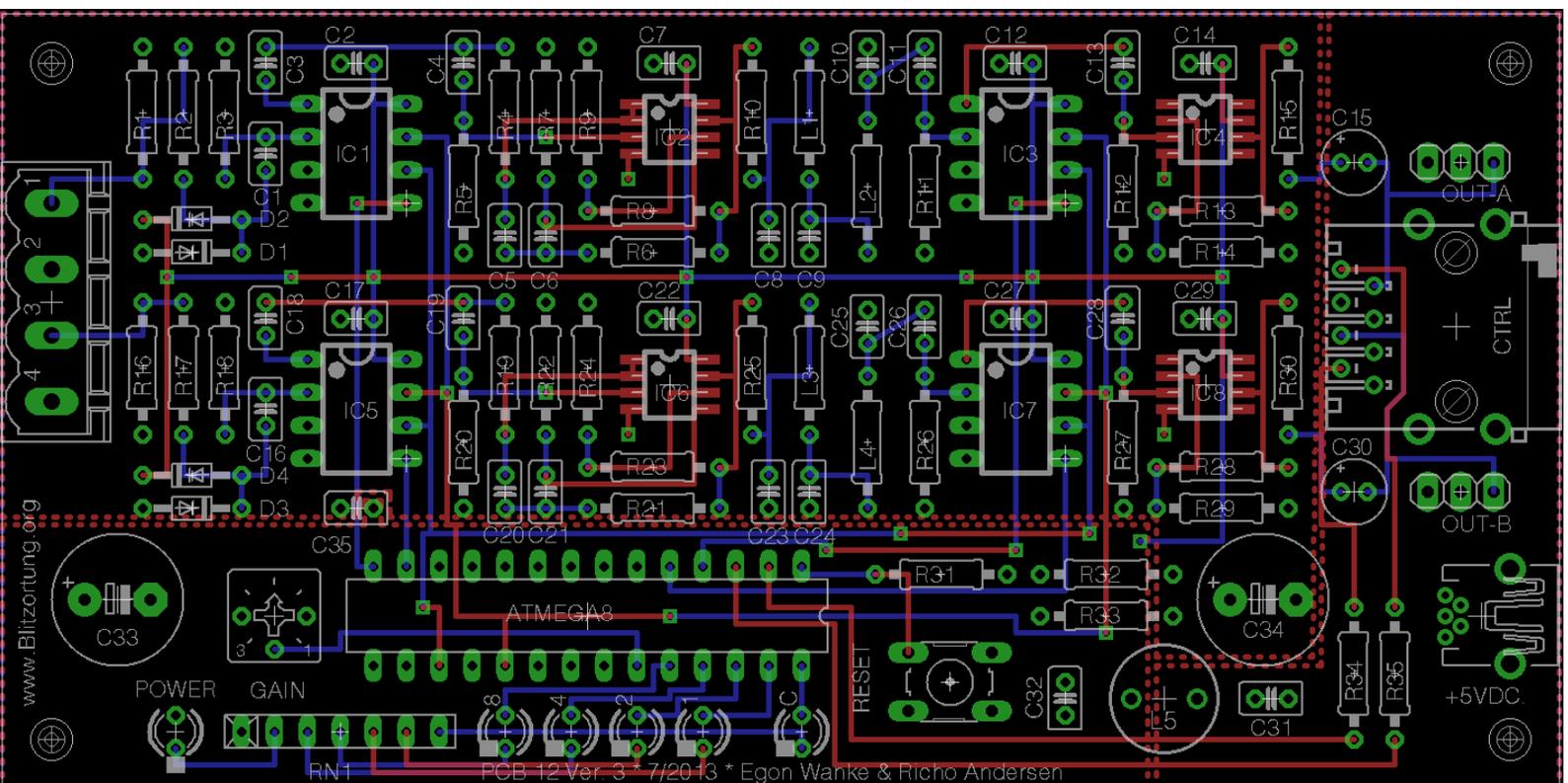
Figure 4: The Printed Circuit Board of Amplifier 12 Version 3

Amplifier 12 Version 3

MCP6S92 **MCP6292** **MCP6S92** **LM6642**

Antenna Input A

Ground

Antenna Input B

Ground

Output Control Channel A

Connection to Controller, RJ45

Output Control Channel B

Power Supply, 5 Volt Mini USB

Power Indicator   **Gain Index**   **Reset**

Manual Gain Adjustment   **Automatic Gain Controll Indicator**
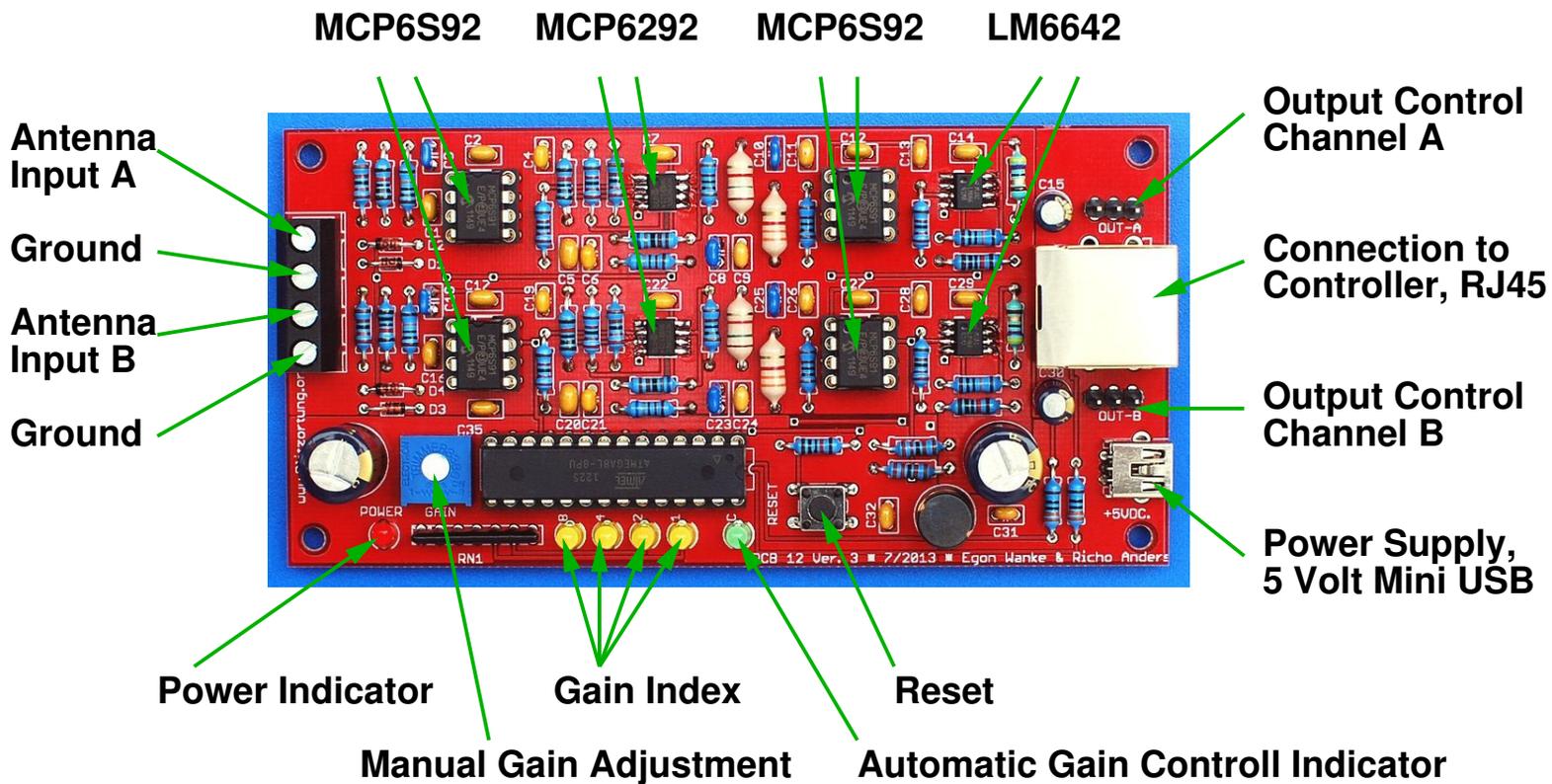
Figure 5: An assembled Amplifier 12 Version 3

1.3   Controller board

The heart of our Controller 12 Version 3 is an 32-bit ARM Cortex-M4F micro-controller. This controller has 1 MB Flash, 192 KB RAM, and is running with a clock frequency of 168 MHz. Controller 12 Version 3 uses the STM32F4DISCOVERY board which also includes an ST-LINK/V2 programmer. The use of this breakout board is only a temporary solution. If the controller works fine with the breakout board then in a later version we will place the ARM Cortex-M4F micro-controller on our controller board.

The ARM Cortex-M4F micro-controller has three 12-bit analog-to-digital converters. These converters are capable to provide a throughput of up to 1,000 ksps= 1,000,000 samples per second even if both input jacks of the controller board are multiplexed. The DMA of the controller is used be store continuously the converted signals into the memory such that we can read out the signal samples stored before the signal reaches a threshold.

The block diagram, circuit diagram, printed circuit board, and an assembled circuit board of Controller 10 Version 3 are shown in Figure 6, 7, 8, 9, and 10, respectively.

1.3.1   Electronic parts

The electronic parts necessary for Controller 10 Version 3 are listed in Table 3. The additional necessary mechanical parts can be found in the complete part list, see table **??**.

1.3.2   STM32F4DISCOVERY board

The STM32F4DISCOVERY board is placed piggyback on the controller board. It has two push buttons, a black reset button and a blue user defined button. The functionality of the blue push button depends on the state of the program. The four user defined LEDs, LED3 (orange), LED4 (green), LED5 (red) and LED6 (blue) are used to indicate the received signals, the GPS state, the 1PPS signal, the interference mode and other problems.

The other additional hardware of the STM32F4DISCOVERY board is not used by the controller. This especially concerns the motion sensor, the accelerometer, the microphone, and the audio DAC.

1.3.3   LEDs

When booting up, the different combinations of the four glowing LED show the steps of the initialization phases. The may be helpful for investigating problems. There are other LEDs on the STM32F4DISCOVERY. One big red/green LED left to the mini-USB connector for the ST-Link firmware programmer and a small red LED on the opposite site as power indicator. Both LEDs can not be controlled by the CPU, so the ST-Link LED is blinking all the time when no USB connection is available. There is another red LED close to the micro USB connector. It can light up when using the analogue user input.

Breakout board		STM32F4DISCOVERY	
Display		LCD 122DIP	
GPS module		GlobalTop PA6H (MT3339)	
Ethernet Controller		ENC28J60	
Voltage transformer		LF33CV	
Transistors	T40, T41	BC338	
LEDs	GPS fix LED	LED 3mm (green)	
Diodes	D40, D41, D42, D43, D44, D45, D46, D47, D48, D49, D50, D51	1N4148	
	D52, D53, D54, D55, D56, D57	1N5818	
Resistor, metal 1%	R47, R55, R56, R65	10kΩ	
	R46, R50, R52, R53	2.2kΩ	
	R62, R63, R64	1kΩ	
	R40, R41, R57	680Ω	
	R54	470Ω	
	R58, R59, R60, R61	330Ω	
	R42, R43, R44, R45	49.9Ω	
	R48	47Ω	
	R49, R51	10Ω	
Resistor network, star, 8-9	RN42	10kΩ	A103
Resistor network, 3-6	RN41	1kΩ	B102
Resistor network, star, 8-9	RN40	100Ω	A101
Capacitors, electrolytic, 5mm	C45	470 μF	
2.5mm	C44, C48, C55, C56	100 μF	
Capacitor, ceramic, 2.54mm	C40, C43, C46, C47, C49, C50, C51, C52, C53, C54, C57, C58, C59, C60, C61	100 nF	(104)
	C41, C42	18 pF	(18)
Inductances, HBCC	L40, L41, L42	10 μH	
Crystal		25 MHz	

Table 3: The electronic part list for the controller board Number 10 Version 3

1.3.4   Display

The LCD DIP122 graphic display provides a 122×32 dot matrix and is used to show informations about the system. The dot matrix allows to display graphical symbols and graphical informations beside letters and digits. The user can see the state of the network, the state of the GPS module, the state of the amplifiers, and many other useful informations. The display is available with different LED backlight colors. We recommend the most robust and cheapest green display whose size is only $67\text{mm} \times 27\text{mm}$. However, the contrast and brightness is more brilliant on the amber display than on the green and blue display. The amber and blue displays have a size of $75\text{mm} \times 27\text{mm}$ and are a little bit more expensive than the green displays. The green backlight has a higher power consumption than the other ones. The backlight is driven through a transistor, which is connected to a PWM output of the controller. Thus, the

brightness can be adjusted by software. A charge pump, which is driven by another PWM of controller, converts 3V to around -5V for the contrast voltage. The correct voltage depends of the display type, supply voltage and temperature. The LCD has an integrated temperature compensation, so the contrast should be stable even when you use the LCD outside.

1.3.5   Buzzer

The buzzer of the controller board allows to indicate different states and events by different sound signals. For example, every received signal can be indicated by a beat sound. The buzzer can output an alarm if the system enters the interference mode or if the network connection is lost. The buzzer can also be used as a loudspeaker which allows to output the received VLF signals. This provides a very useful tool to find sources of interferences and thus to find the best place of the antennas in a noisy environment. In any case, the buzzer can also be turned off.

1.3.6   GPS Module

The controller needs a GPS device with a serial TTL level interface and a 1PPS signal. We recommend to use the on-board GlobalTop PA6H GPS module. This module allows you to connect an external antenna with an SMA connector. Most external antennas have a connection cable between 2 and 5 meter. The longer the cable the larger the loss. The green LED beside the GPS module stops blinking when the GPS has found its position.

If you do not want to use the GlobalTop PA6H GPS module, we recommend to use the NaviLock or GlobalSat EM-406A GPS module. The pin assignment of the GPS connector on the controller board is shown in Table 4. This pin assignment is identically to the pin assignment of the EM-406A. Although other GPS modules will work, the firmware of the controller currently only supports the MediaTek MT3339 and SiRF chip sets.

Pin	← EM-406A module	GPS Connector →	Pin
1	ground		1
2	+5 Volt		2
3	serial input TTL		3
4	serial output TTL		4
5	ground		5
6	1PPS output		6
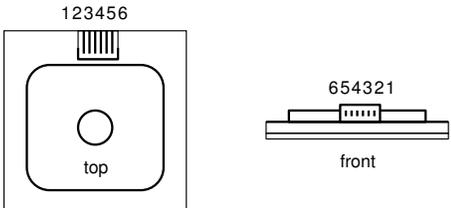
Table 4: Pin assignment of the EM-406A module and its connection to the GPS connector

1.3.7   Amplifier connectors

The Controller 10 Version 3 has two RJ45 connectors for two amplifiers with maximal 3 channels. The firmware automatically detects to type of the connected amplifier. Both connectors can be used independently. Please do not connect old amplifiers version 5.x and before!

1.3.8   Ethernet

The controller board is connected to a local area network by a shielded CAT network cable to the RJ45 network connector. This jack has integrated transformers and LEDs. There are only very few compatible jacks, so have a close look into the datasheets when you want to use another connector! Although the ARM Cortex M4 based STM32F4 micro-controllers already have an internal Ethernet controller, they do not include an Ethernet Physical Layer Transceiver (PHY). For experimental reasons, we additionally have placed the Ethernet controller ENC28J60 on the board of Controller 10 Version 3. The ENC28J60 a very widely used "all-in-one" ethernet controller, but it can only handle 10Mbit/s enthernet connections. It has a relatively high power consumption of araound 150mA. The ENC28J60 is connected to the processor via SPI. In a forthcoming version, we intend to remove the ENC28J60 and to replace it by an Ethernet Physical Layer Transceiver on the controller board. Then we will use the internal Ethernet controller of the processor, which uses DMA and can also handle 100MBit/s connections.

1.3.9   Serial interface

The board has a 3.3V TTL level serial interface, which is 5V tolerant. This interface can be used for debug purposes. The connector also provides the power supply for a TTL to RS232 or TTL to USB converter. The pin assignment is printed on the board and can also be found in the schematic.

1.3.10   First hardware check

For the first hardware check, do not connect anything. Remove the STM32F4DISCOVERY board and remove the display. After connecting a 5V USB power supply, the green GPS fix LED should start blinking, if you are using the GlobalTop PA6H GPS module. Next remove the power supply and mount the STM32F4DISCOVERY board and the display. Close Jumper 1 only if you are using the green display, otherwise, if you are using the amber or blue display, open Jumper 1. Then connect the power supply again at the mini USB connector of the controller board, not at the mini USB connector of the STM32F4DISCOVERY board. Some of the LEDs on the STM32F4DISCOVERY board should start blinking. The display should not show anything, because the STM32F4DISCOVERY board do not contain our firmware yet. The next step is to upload the firmware. Note that the mini USB connector on the STM32F4DISCOVERY board is only used to program the board.

Figure 6: Block diagram of Controller 10 Version 3

GPS

RJ-8
From Amplifier

Channel-1

A
B
C

Gain
control

Channel-2

A
B
C

Gain
control

MicroController
32 bit
Discovery
STM32F407VG

Display
122 x 32 Dots

Ethernet
Controller

RJ-8
To Internet

5 Volt
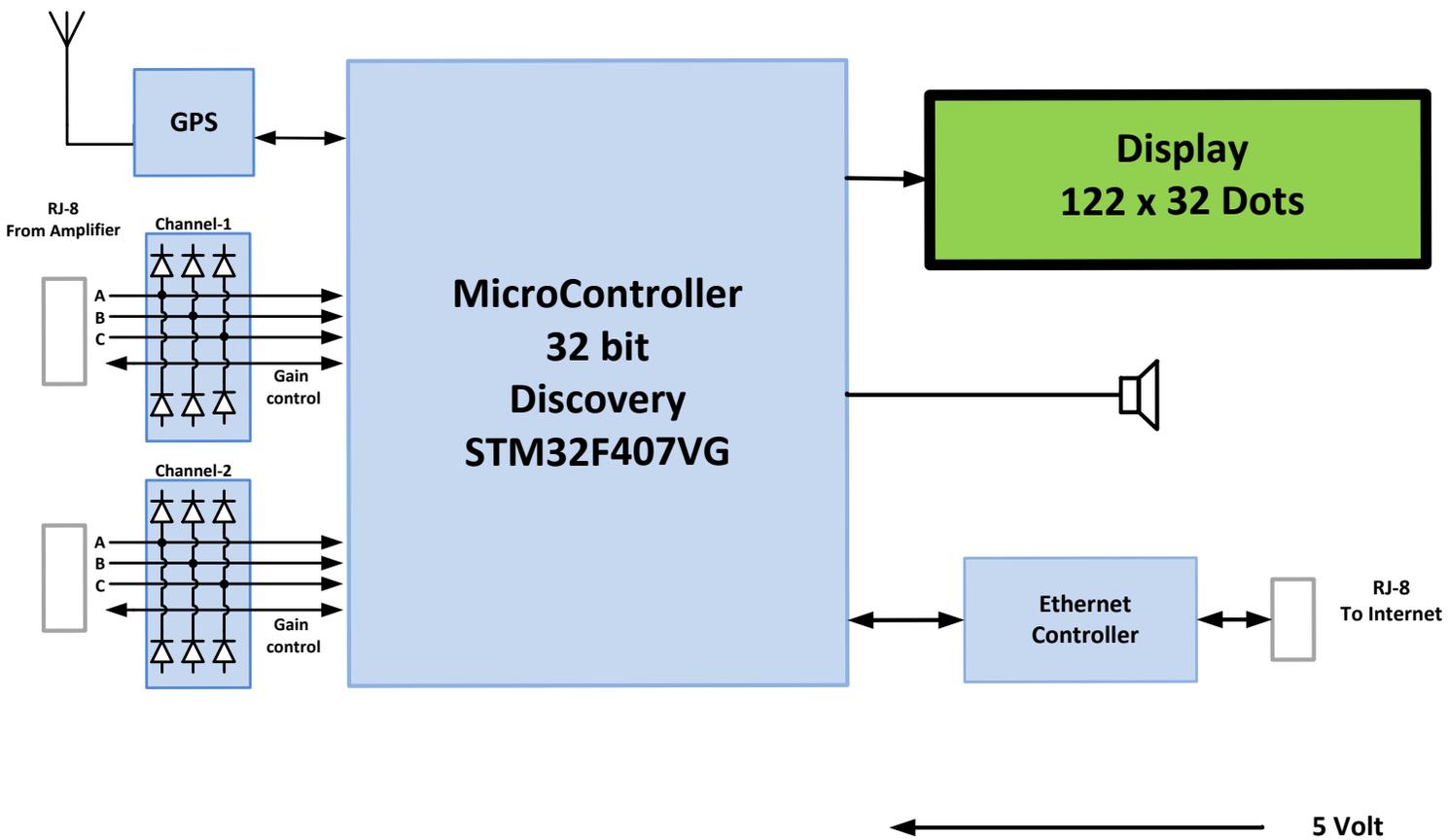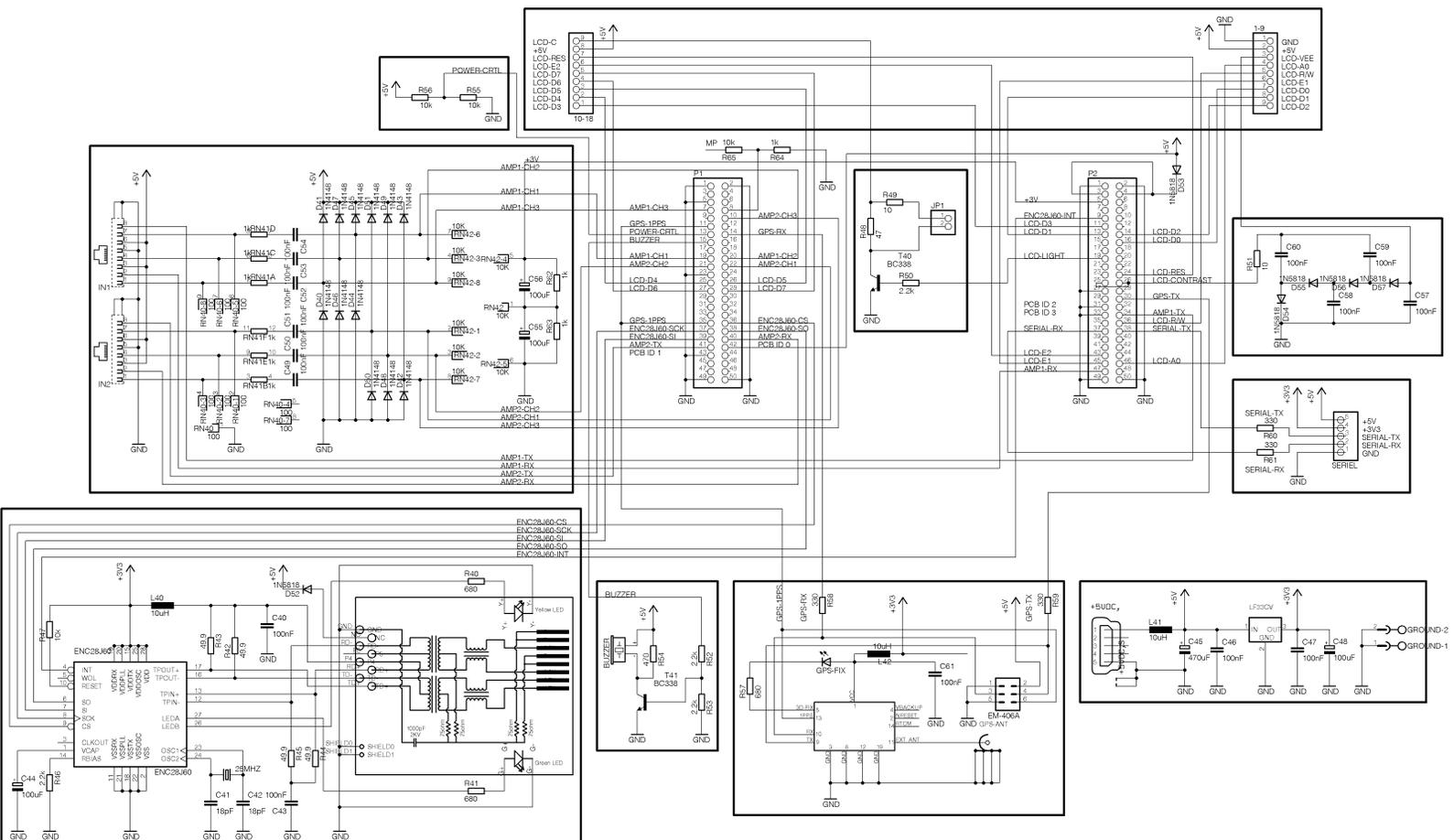
Controller 10

Figure 7: Circuit diagram of Controller 10 Version 3
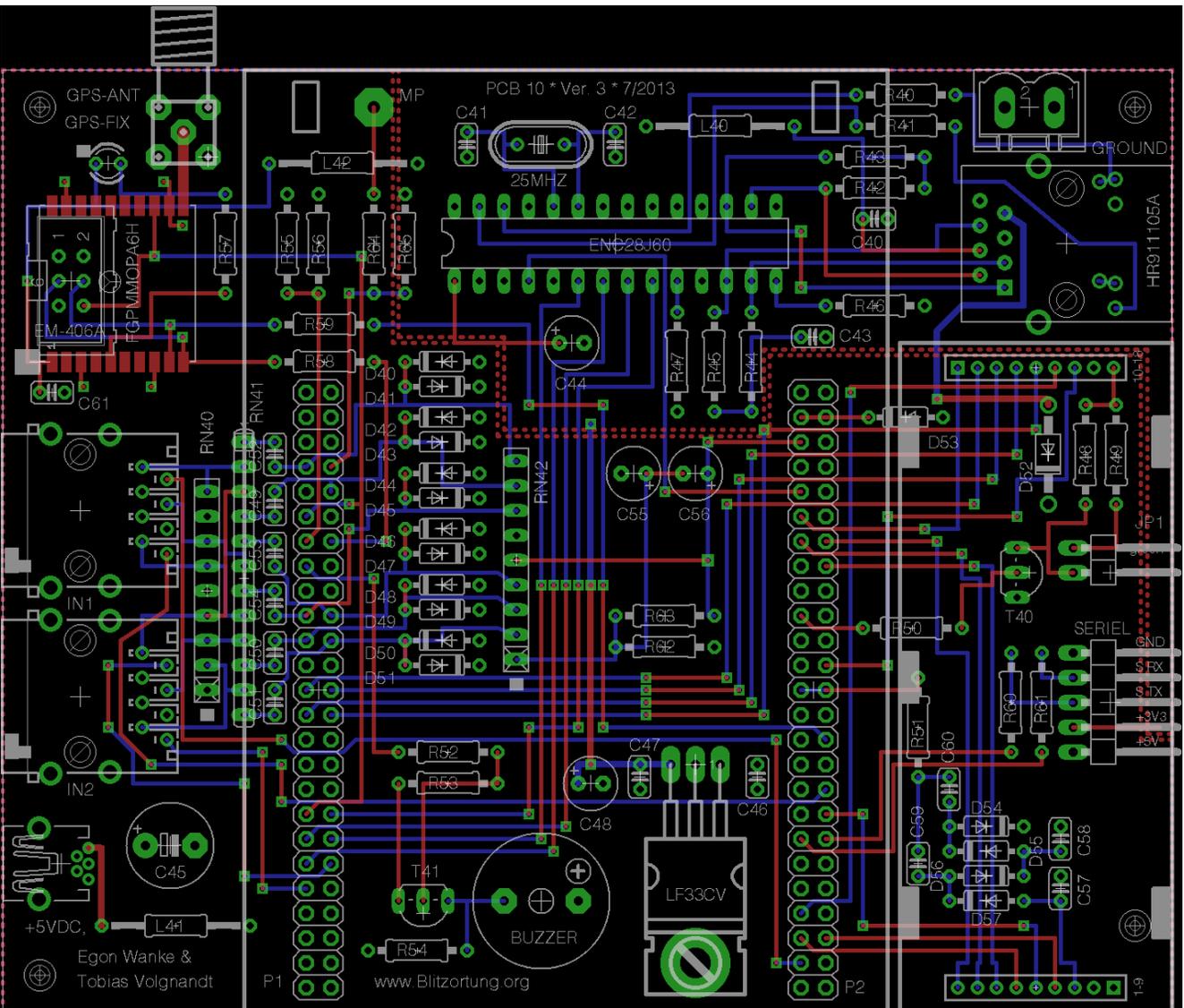
Figure 8: Printed Circuit Board of Controller 10 Version 3

Controller 10 Version 3

ENC28J60 Ethernet Contoller

GPS External Antenna, SMA

GPS Fix Indicator

GPS Modul

Amplifier Input A

Amplifier Input B

Power Supply, 5 Volt Mini USB

Grounding

Local Area Network

Jumper 1, open for amber and blue Displays

Serial Interface

Buzzer
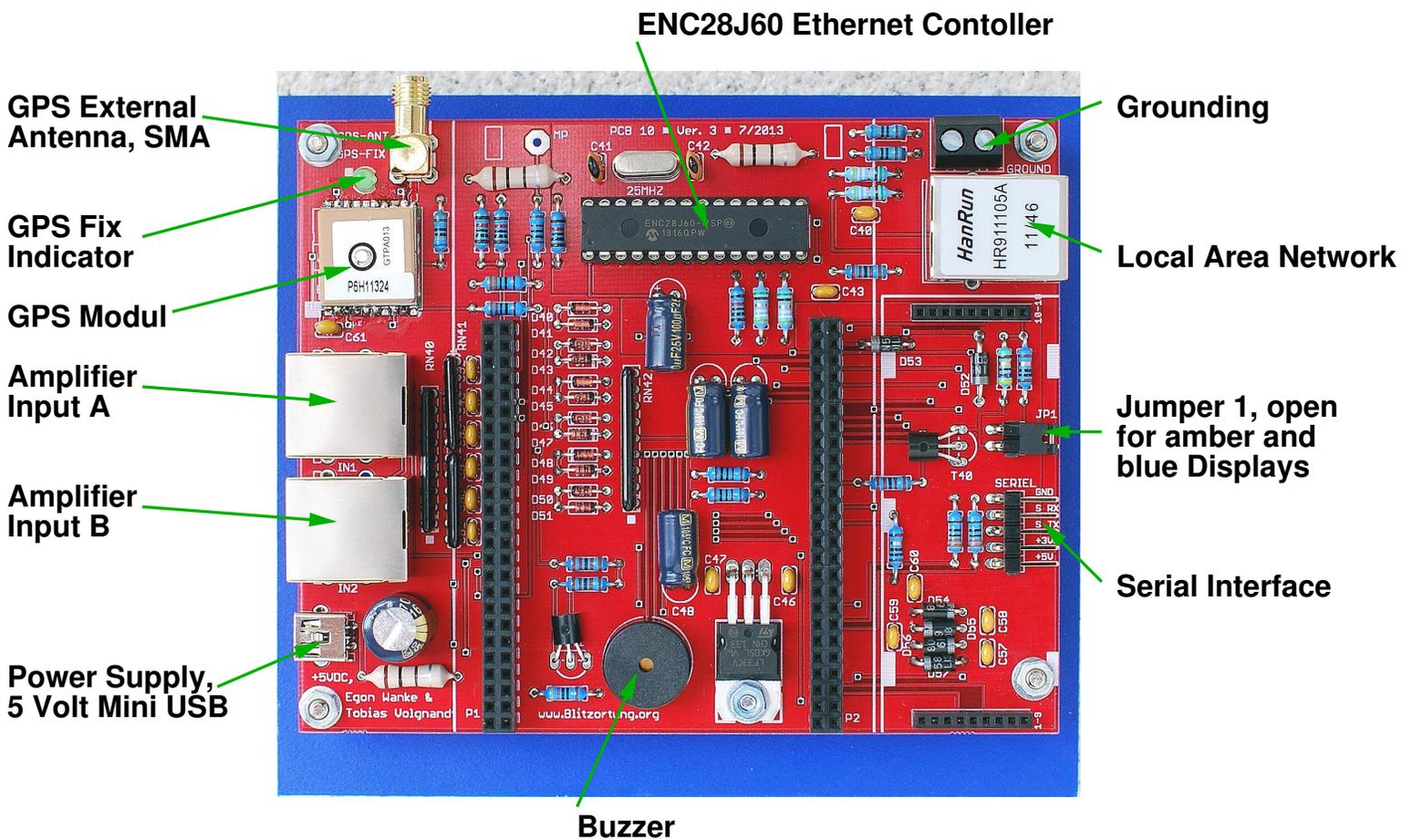
Figure 9: Assembled Controller 10 Version 3

Controller 10 Version 3

USB Connector for Firmware Programming
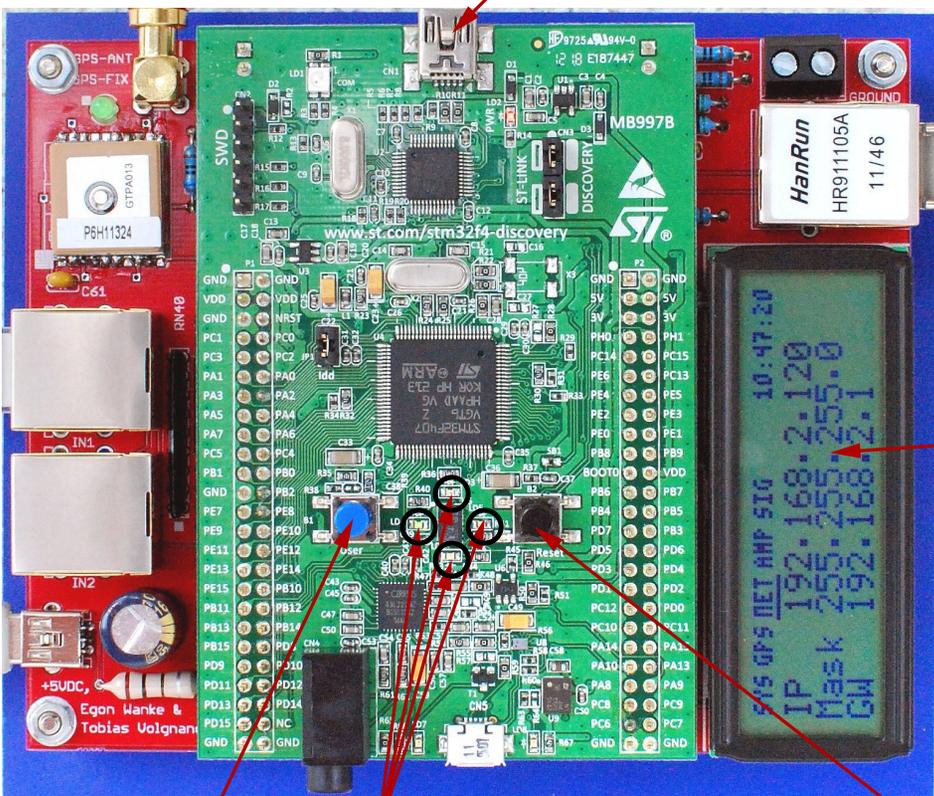
LCD Grafik Modul, 122x32 Dot Matrix, LED Backlight

Menue　　**blue, orange, green red LEDs**　　**Reset**

1.4   Power supply

The amplifier and the controller can be powered by a 5V USB power supply. Both boards have a mini USB jack. The mini USB jack of the STM32F4DISCOVERY board can not be used to supply the system. This jack is only used for programming the STM32F4DISCOVERY board. The +5V line of both boards are connected via the connection cable. It is neither necessary nor recommended to power the system at both ends. We recommend to power the system at the controller site.

When the boards get power the red power indicator LED on the amplifiers lights up. On the controller board the power on LED of the STM32F4DISCOVERY board and some of the other LEDs will be light on. The power consumption of the amplifier and controller is about 40 mA and 400 mA, respectively.

1.4.1   PoE

The system can also be powered over the Ethernet connection cable if the J0006D01BNL RJ45 Ethernet Jack from Pulse Electronic is used. This Power over Ethernet (PoE) technique use pin 7 for +5V and pin 8 for ground. To inject the power, a simple PoE injector is needed. As only 5V is used as supply voltage, the network cable must not be longer than a few meters. If the voltage drop is too high, you can try to inject up to 6V. Don't use higher voltages! Note: This pseudo PoE is not compatible with the official IEEE standard 802.3af!

1.5   Grounding

The receiving system should have a good ground to operate efficiently. The ground of the amplifier and thus also the ground of the controller board should be connected to a large expanse of metal such as a safety hand rail around a roof or a heating core. Note that the ground of the system should never be connected to the ground wire of the electrical supply system. Usually some grounding is already given if the shielded network cable is connected to the router. The controller has a special terminal block for grounding, see also Figure 9.

1.6   Assembling advice

The expected assembling time of the amplifier and controller together is approximately four hours. Most problems are caused by working too fast or too superficial. The parts should always be soldered according to their mounting height.

1. Parts with a low mounting height:

   SMD op-amps, diodes, resistors, ceramic capacitors, axial inductances, the crystal

   - Pin 1 of the ICs is marked by a dot at the housing. These pins are marked by a white dot at the boards.
   - To mount the SMD parts (IC2, IC4, IC6, IC68 and the GlobalTop PA6H GPS module), first solder only one of the four corner pins. Then unsolder and solder

this pin repeatedly until the component is properly placed. After that solder the other pins. It is not necessary to use solder paste.

- The cathode ($-$) of the diodes is marked by a black or white ring at the housing. These sides are marked white on the boards.

- The values of the resistors should be verified by a multimeter, because it is sometimes difficult to distinguish between certain colors, as for example, between red and brown.

2. Parts with a medium mounting height:

sockets, mini USB jacks, LEDs, push-button, potentiometer, resistor networks, the GPS module, transistors, the voltage transformer, mount sockets for the display

- The anode ($+$) of a LED has a longer wire than the cathode ($-$). The hole for this wire is marked by white squares on the board.

- A resistor star network has a dot at one side. This side has to be placed at the crossed pin beside the red power LED.

- The transistors and some of the radial electrolytic capacitors have to be folded down on the controller board such that the STM32F4DISCOVERY board and the display have enough space.

- The two 1×10 mounting sockets for the display have to be shortened to 1×9 by pinching off the last pin with a cutter and smoothing the border with a file. To ensure that the mounting sockets for the display will be correctly aligned, carefully insert the display's pins into the mounting sockets before soldering them to the controller board, see also the hint for soldering the mounting sockets for the STM32F4DISCOVERY board.

3. Parts with a high mounting height:

radial inductance, radial electrolytic capacitors, terminal block, buzzer, headers for the output control, board mount sockets for the STM32F4DISCOVERY board, RJ45 jacks

- The positive pole of an electrolytic capacitor has a longer wire. The hole for this wires is marked by a $+$ symbol.

- The center pin of the 3-pin header for the test pin of the amplifier can be removed. It is not connected.

- To ensure that the double row mounting sockets for the STM32F4DISCOVERY board will be correctly aligned, carefully insert the STM32F4DISCOVERY board's pins into the mounting sockets before soldering the sockets to the controller board.

- On the Buzzer there is sticking a sign marking the positive pin.

2   Operating Instructions

The lightning detector is put into operation as follows:

1. Write a short email request to blitzortung@gmx.org for a new user account if you do not already have one.

   You need only one account independently of the number of station you operate and regions you supply.

2. Install the System RED firmware on the STM32F4DISCOVERY board as described in Section 2.1.

   The link to the firmware pages can be found in the services section of www.Blitzortung.org.

3. Connect the controller to a local area network using DHCP and use a web browser to open the web interface of the controller where you can adjust the lightning detector, see Section 2.3.

   You find the IP address of the controller at the Display.

4. Assign the station at the `Services→User-data` page of www.blitzortung.org to your user account. That is, insert the Device-ID of your STM32F4DISCOVERY board to the field "Assign a new Station by Device-ID:" and acknowledge by "Save".

   You will find the 24 digits hexadecimal Device-ID on the webpage of the controller at the `Status` page in paragraph `Controller/CPU` paragraph. Do not insert the "-" characters between the 4-digit blocks.

5. Check from time to time that your system is still running and then enjoy your lightning detection.

2.1   Firmware Installation

The firmware on the STM32F4 controller is the heart of the system RED. It initializes and controls all peripherals and does the communication with the servers. Compared to the old system, the firmware is very complex but also very powerful. Especially during the first months after start of system RED, there will be several updates to improve stability and add new features. Hint: Never flash any other 3rd party firmware on the STM32F4DISCOVERY, while it is connected to our PCB! Otherwise parts on both of the PCBs or the CPU might be damaged!

After assembly of the system, you have to install the firmware over the dedicated USB port. There is already a small pre-flashed firmware on your new STM32F4DISCOVERY, which and lets the LEDs blink according to accelerometer value. This is only a demonstration and it will be overwritten by our firmware. The flash procedure is easy and takes only some seconds. It is almost impossble to brick the STM32F4DISCOVERY, even if you pull the cable while flashing. Please never set any user option bits, otherwise the flash might be write protected forever!

2.1.1   Flashing

There are several tools for flashing the STM32 family on different operating systems. For the following description, we use the official STM32 ST-Link utility (version 3.0.0). First of all, get the tool from the following address: http://www.st.com/web/en/catalog/tools/PF258168. If you don't find the download, then try Google. After download, run the setup. The driver is also included in the package. Follow these steps, to program the flash:

1. USB connection: Connect the mini-USB jack on the STM32F4DISCOVERY with a cable to your computer. If you do this the first time, the driver will be installed, which can take a while. While connected to the USB port, the CPU gets the necessary power from your computer. It doesn't matter whether the system is powered by external 5V or not while flashing. There is no need to remove the Discovery from the red PCB, as there is a good chance to damage it mechanically or electrically during this procedure. When the connection is established successfully, the big ST-Link LED should stay red. If it is blinking red, then there is a connection or driver problem.

2. Open the programmer window 11: Start the *STM32 ST-LINK Utility*. In this tool, select *Target → Program...* from menu, click *Browse* and select the Firmware (.bin) file.

3. Start flashing 12: Check if the Start address is 0x08000000 and click on *Start*. The data is now programmed into the flash. It takes several seconds.

4. Reset: If the CPU didn't perform a reset after flashing is done, simply press the black button.

2.1.2   Windows 8 Driver Installation

The driver itself works perfectly with Windows 8 (32 and 64bit), but unfortunately it is not possible to install the driver the usual way, as it doesn't have a valid signature. You must disable this check with the following procedure:

1. Press Windows+I and you will see the Charms Bar

2. Click on power while holding the Shift key and select Restart

3. After some seconds, you should see a troubleshooting page. Select Troubleshoot and then Advanced Options.

4. Then select the Startup Settings and click Restart again. The system performs a reboot.

5. In the boot menu, press 7 or F7 to disable the driver signature check.

6. Now you can install the driver.

This procedure has to be made only once or when changing the driver!
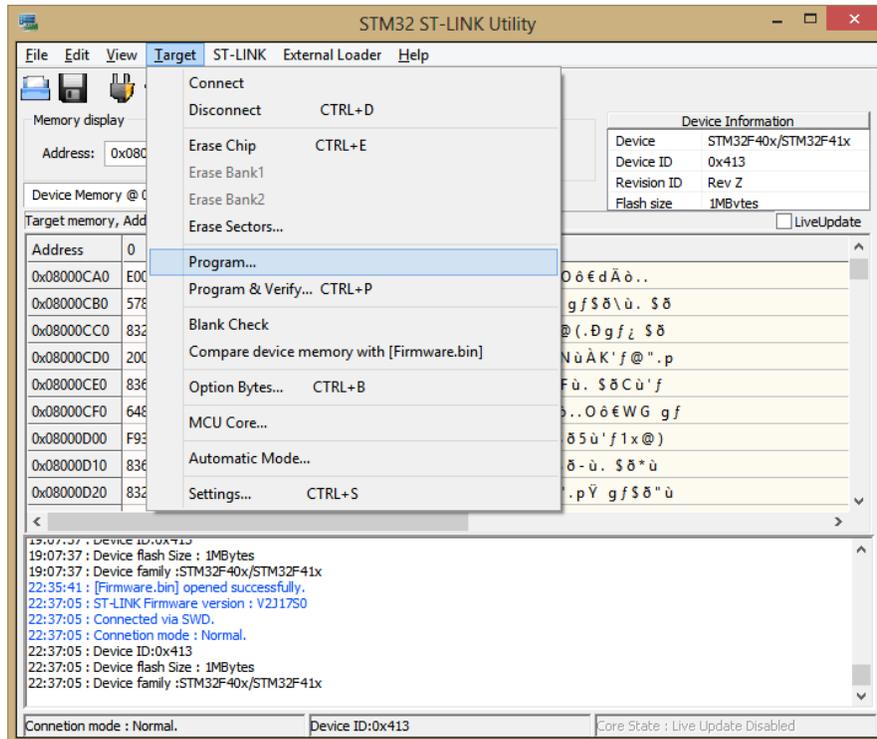
Figure 11:   Open the programmer window
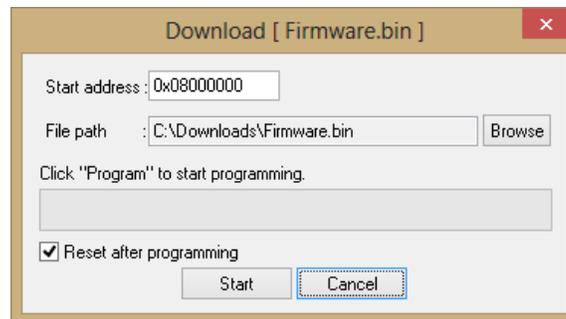
Figure 12:   Start flashing the new firmware

2.1.3   Alternative Firmware Flash Methods

The CPU has an integrated boot loader, which is write proteced. This boot loader allows programming the flash through the serial or USB interface. There is currently no need of using this feature, but it already works when connecting BOOT0 and VDD with a jumper. In future releases, there could be a feature to update the firmware through the network connection, i.e. via web interface.

2.2   Button, LCD, LEDs

Green LED

The green LED starts blinking when the controller receives data sentences from the GPS, it will keep glowing, when the controller receives "active" data sentences.

Blue LED

The blue LED flashes every time the controller get a 1PPS signal.

Orange LED

The orange LED flashed every time the controller receives a signal from the amplifiers that reaches the adjusted threshold.

Red LED

The red LED will be blinking constant and slowly if the system has entered the interference mode. If signals can not be send, i.e. because there is no network connection or no valid GPS signal, then the red LED blinks at the same time as the orange LED.

2.2.1   Reset

2.2.2   Restore settings

2.3   Web Interface

2.4   Using Serial Output

3   Frequently asked questions

In this section, we try to answer most of the most frequently asked questions. Before you ask us anything specific you first should inspect the following list of questions and answers. This will save a lot of time for both of us.

Question 1:   Where can I get a lightning detector for participating Blitzortung.org and what is the price?
First of all, you have to assemble your lightning detector by yourself. We do not offer complete assembled station. We only offer certain parts or kits. Sometimes participants of Blitzortung.org assemble stations for friend and others. We can not give here any names or addresses of these friendly people. The best place to find them is a forum. You will find some links to lightning location forums on our webpages.

   The total price for the necessary parts is less than 200 Euro. The prices will differ from country to country. Note that this is only the price for the real necessary material. It does not include a housing for the assembled boards or the material to mount the antennas under the roof or outside. However, it is not strictly necessary to use a housing or a water proof out-door mounting. Many participants have mounted the components on a plastic board and use ferrite rod antennas in-doors. What you additional need in any case is a wired internet connection, two days of time for assembling and installing such a system, and some experiences in soldering electronic components. Building a lightning detector and its operation is not *plug and play*.

Question 2:   What is the detecting range of a station?
This question is similar to the question "How far can I see?" If it is foggy, you can not see more than 50 meters, but on a starry night you can see stars having a distance of lightyears. If a lightning discharge is very strong and the propagation conditions are well, the signal can be received over several thousands of kilometers even with small antennas. This is the case especially at night over the ocean. If a lightning discharge is very weak, it is difficult to receive it even with large antennas in a distance of only 50 km. When using 20 cm ferrite rod antennas you will receive signals from thunder storms up to 1000 km at day, and over 2000 km at night. If you use larger antennas in more quiet environments, the signal to noise ration will increase, and you can receive signals up to 3000 km. This also depends very much on the location of the antennas. The range will increase dramatically if your antenna is placed in an electromagnetically quiet area outside a city on a hill and it will decrease if it is placed in an urban area inside a building.

   Some participants are more interested to receive close lightning discharges instead of distant lightning discharges. They waive the long range fine tuning and concentrate to trim the system for close lightning discharges. The challenge to receive close lightning discharges such that they can be used for the computations is to separate pre- and post-discharges from the

main stokes.

Question 3:   What is the detection accuracy of the system?

We do not know.

Question 4:   Why do we need a GPS?

The main reason why we use a GPS module is the time measuring. The TOA (time of arrival) lightning location method is based on a high precision time measuring of the lightning discharge with an accuracy of less than $\pm 1 \ \mu \ s$. A time difference of $\pm 1 \ \mu \ s$ corresponds to an distance difference of $\pm \ 300 \ m$. Such a high precision time measurement is only possible with a GPS module that outputs a 1PPS (1 pulse per second) signal. Other techniques like using the DCF77 signal are not adequate for such a high precision time measurement. The additional output of the exact geographic position of the site is a pleasant side effect of GPS devices.

Question 5:   Where should I place the GPS antenna?

GPS antennas should always be placed outside or at least at a window, because frequencies between 1 and 2 GHz can not pass dense matter very well. You can verify this also with your car navigation system.

Question 6:   What are the best distances between the detectors?

Lightning detectors are best placed in a distance between 50km to 300km around the lightning discharges. However, even if there is another station nearby, it is still interesting for the project to place a station beside the existing one. The reason for that is very simple. Only 50 % of all stations will work continuously and only 50 % of the running stations are perfectly adjusted. The TOA lightning location network is based on "Give and Take". Your station best contributes to the computations if it is placed in a distance between 50 km and 300 km from the discharge. If the storm is nearby, your station usually overrides. Even a very low pre-discharge will cause a very high signal strength because of its low distance.

Question 7:   Can I get the source code for the Firmware and the layout data of the PCBs?

In recent years, our lightning detection system growth and become more popular and more successfull. Unfortunately, this also increased the number of people who just want to copy our system instead of joining our community. To protect our work in that we have invested several thousands of hours of our free time, we provide the sources of the Firmware and the layout data of the PCBs only for selected familiar members of the project which we already

know for a long time.

Question 8:   How should I align the antennas?
To do...

3.1   Common Problems

Problem 1:   The display has dark bands across it when the board is powered
You are probably using the mini USB jack at the STM32F4DISCOVERY board for the power supply. Please use the mini USB jack of the controller board for power supply. It is not possible to use the mini USB jack of the STM32F4DISCOVERY board to power the controller with 5 Volt. This is the most frequently made ??error.

Problem 2:   Nothing is working, only the two red LEDs near the mini-USB jack of the STM32F4DISCOVERY board are glowing!
This means, the CPU is not working. If this happened after uploading the firmware, then the flashing was not successful. Please double check the settings in the flash tool. Is the jumper close to the CPU putted on the pins? If not, then the CPU has no power.

Problem 3:   I don't see any readable information on the LCD!
First check, whether the board is powered via the mini USB jack of the controller, and not via the mini USB jack of the STM32F4DISCOVERY board. Then check, if you accidentally set the LCD contrast to 0 in the settings. Measure the contrast voltage with a volt meter. It has to be around -4V. If this is ok and the display still doesn't show anything, then the communication between controller and LCD might be broken. Carefully check every pin.

Problem 4:   The LCD backlight is not working!
Check, if you accidentally switched the backlight off in the settings. The backlight does not work, when the controller has no firmware.

Problem 5:   I can not connect to the web interface!