MadExp HV

5V to 900V step-up converter manual

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PLEASE, FIRST READ ALL THIS MANUAL, MAYBE PRINT IT FOR QUICK REFERENCE, THEN USE THE BOARD!!!

Contents

INTRODUCTION

The MadExp HV is a 5V to 900V step-up converter. It is specifically designed as power supply and pulse counter for Geiger tubes or PMT tubes. It's output voltage is selectable via 4-bit parallel interface or jumpers.

TECH SPECS

- Size: 46x50mm
- Weight: <15 grams with OLED
- Input: 5V stabilized @ 10mA with OLED (much lower current without)
- Output short circuit current @ 200V: 16µA
- Output short circuit current @ 900V: 75µA
- Built-in 10MΩ anode loading resistor for Geiger
- Built-in but excludible cathode pulse sensing/conditioning circuit
- 4-bit parallel interface for voltage selection.
- 4-bit jumpers for voltage selection
- UART interface for data logging
- 0.96" OLED display as optional
- open source firmware Arduino compatible
- JTAG interface for firmware loading

For higher output current, you can replace the output limiting resistor R18. Change it from the default 10MΩ to minimum 1MΩ.
Many Geiger tubes need a greater anode resistor than 10MΩ so, in this case, you can put in series with the tube a resistor of the needed value.

CAUTION! This device generates high voltage. Output current is within few µA; it's limited by a 10MΩ safety resistor. Take care that the two big ceramic capacitors on the PCB could store enough energy to give you a nice kick if you touch them during operation.
NEVER TOUCH THE BOARD WHEN ACTIVE. NEVER RUN THE CONVERTER AT MORE THAN 500V WITHOUT AN OUTPUT LOAD. NEVER DETACH THE OUTPUT LOAD WHEN POWERED, IT COULD GENERATE AN OUTPUT SPIKE THAT WILL DESTROY THE PULSE SENSING TRANSISTOR. TAKE CARE OF THE CIRCUIT POWER SUPPLY INPUT POLARITY, THERE IS NO POWER SUPPLY INVERSION PROTECTION. THE OUTPUT VOLTAGE COULD GENERATE A SPARK, USING IT IN EXPLOSIVE GAS/AIR/DUST/OIL MIXTURE ENVIROMENT IS VERY DANGEROUS! PACEMAKER PATIENTS MUST USE SPECIAL CARE USING THIS DEVICE. THIS IS NOT A TOY. YOUR FINGERS COULD MAKE AN ELECTROSTATIC DISCHARGE ON THE BOARD'S CPU IF IT TOUCHES THE BOARD DURING OPERATION, IT COULD DESTROY IT. SAME THING FOR THE OLED DISPLAY. PLEASE, FIRST READ ALL THIS MANUAL, MAYBE PRINT IT FOR QUICK REFERENCE, THEN USE THE BOARD!!! THIS CIRCUIT FEAR THE AIR MOISTURE. PLEASE DON'T OPERATE IN HIGH MOISTURE CONTENT AT OUTPUT VOLTAGE

VOLTAGE SELECTION JUMPERS

On the back of the board, there are four voltage selection jumpers.
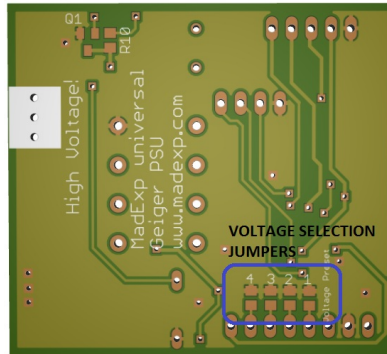
A blob of solder that shorts the PCB's pads making short circuit makes a solder bridge. You'll need a low power soldering iron and some solder to do this. Take care to do not make short circuits between near jumpers pads and to not overheat the board.
Take a look at the table and make your jumpers selection accordingly.

JUMPERS				DECIMAL	OUTPUT
1	2	3	4		
0	0	0	0	0	200V
0	0	0	X	1	250V
0	0	X	0	2	300V
0	0	X	X	3	350V
0	X	0	0	4	400V
0	X	0	X	5	450V
0	X	X	0	6	500V
0	X	X	X	7	550V
X	0	0	0	8	600V
X	0	0	X	9	650V
X	0	X	0	10	700V
X	0	X	X	11	750V
X	X	0	0	12	800V
X	X	0	X	13	850V
X	X	X	0	14	900V
X	X	X	X	15	950V

X = BRIDGE 0 = OPEN

Please note that in order to drive the voltage selection via an external MCU/CPU/microcontroller, all jumpers must be left open.

CONNECTION DIAGRAM

There are three pin strip on the board.
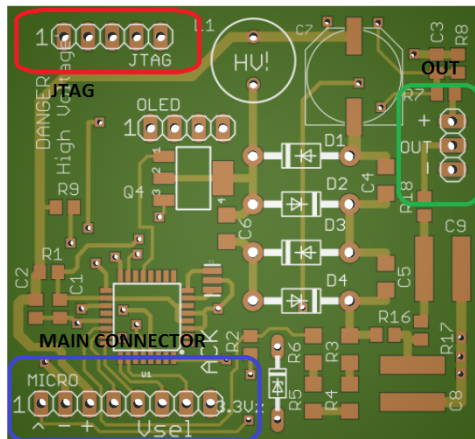
The JTAG connector is used to program the MCU with the firmware.
During normal operation it's used to output serial UART data. 9600bit 8-N-1 no flow control. You can change it in the firmware and also pin 4 (Arduino D12) remains free for custom firmware use.

JTAG for programming pinout
1. GND
2. /RESET
3. SCK
4. MISO
5. MOSI

JTAG during normal operation
1. GND
2. /RESET MCU reset if grounded
3. UART RX
4. Free
5. UART TX

The OUT connector is used to output high voltage and input pulses from a Geiger tube or photomultiplier tube.

- - is the board ground
- OUT is the high voltage output
- + is the cathode/pulse input from the Geiger tube. IT IS NOT THE HIGH VOLTAGE OUTPUT

HIGH VOLTAGE NOISE @400V with SBM20 tube

vertical: 10mv/DIV
horizontal: 10uS/DIV
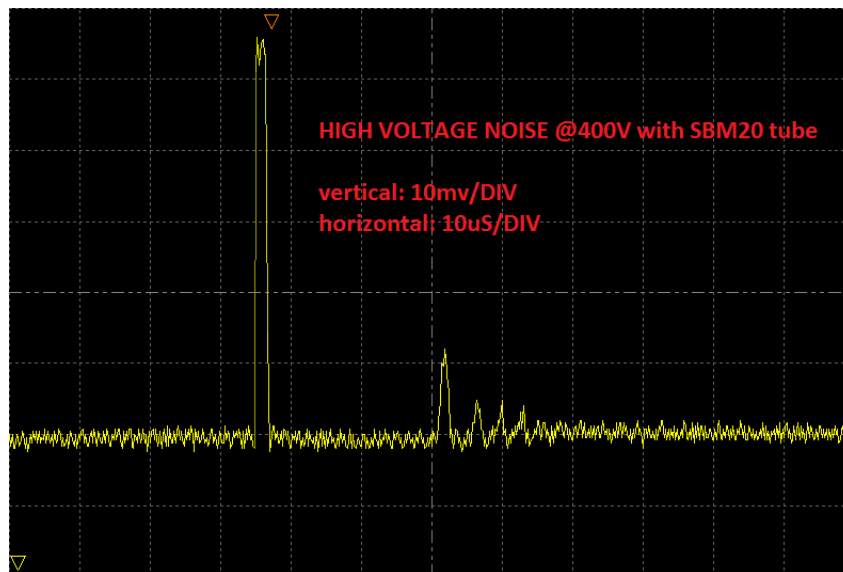
You can use OUT and – to power your own circuit or OUT and + to directly drive a Geiger tube.
In that case the MCU will count pulses and show counts per minute on the OLED display.
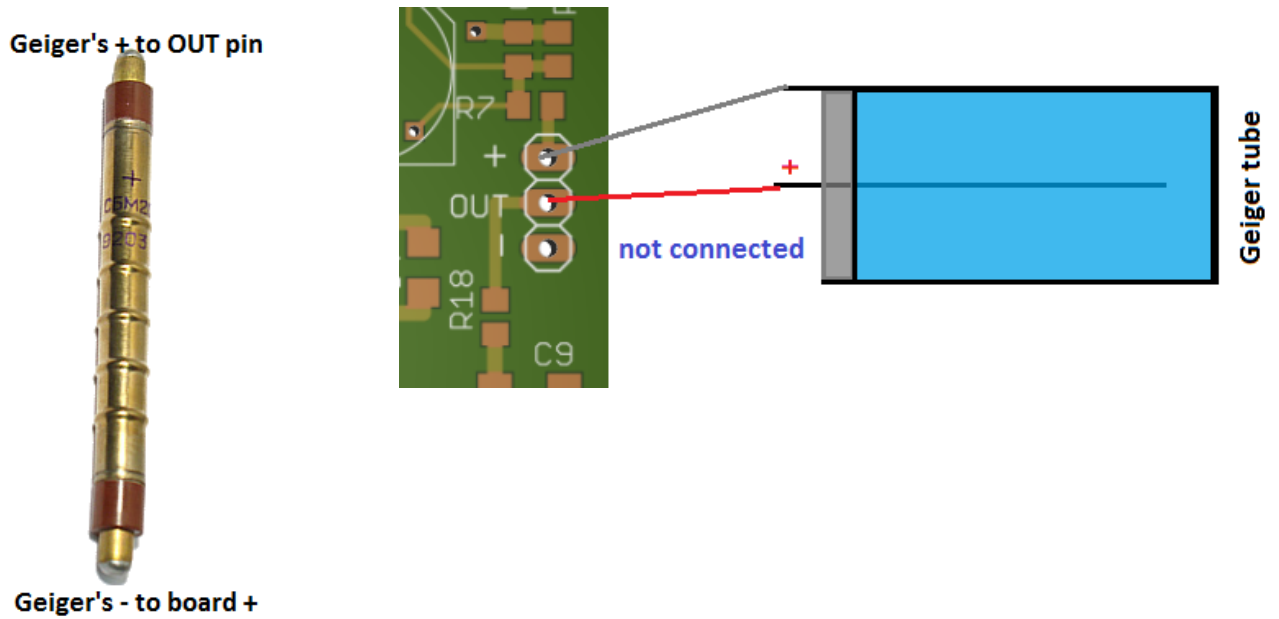
Main connector receives power supply from an external 5V voltage regulator, accept the 4-bit parallel data from an external MCU/CPU, output the voltage pulse from the pulse conditioning circuit and have a multi-purpose pin marked as ACK.
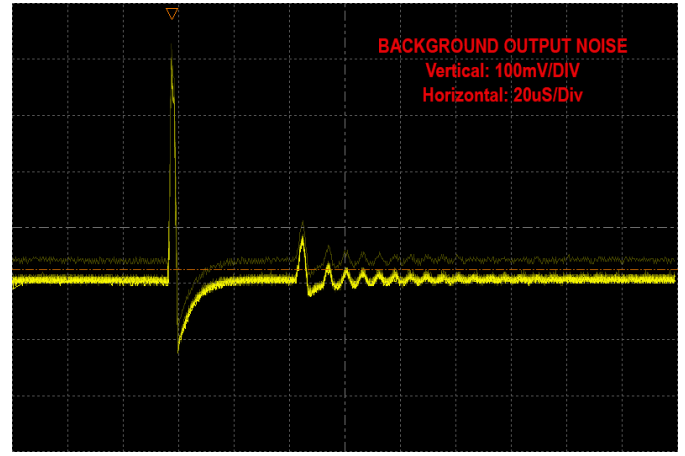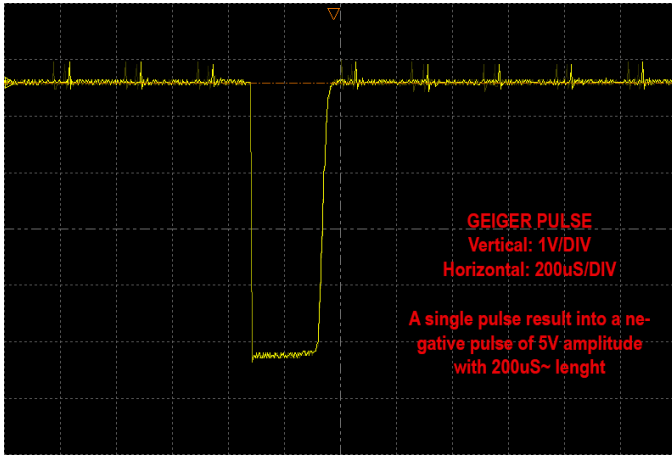
Main connector pinout:
1. Pulse out from pulse conditioning circuit
2. GND
3. +5Vcc input @10mA minimum. Not protected from polarity inversion!
4. 4-bit interface pin 1 MSB
5. 4-bit interface pin 2
6. 4-bit interface pin 3
7. 4-bit interface pin 4 LSB
8. Multi-purpose pin ACK

➢ Output pulse on the pin number 1 is obtained by amplifying the incoming pulse from the Geiger tube, squaring it and expanding the signal.
Output pulse is negative. If you need to count it with external hardware, consider its polarity.
You can modify R8 decreasing it if you have noise issues. A typical noise issue on pulse counting circuit make the counter counting without any load attached to the output. I've fixed this adding a 100pF capacitor (not present into the schematic) near the Atmega-328. It goes in parallel to the interrupt pin to ground and it loads the line that comes from the squaring transistor that is present on the back of the board. With this fix, that is applied on all boards, there is no need to change R8 resistor at all. It works on the complete output voltage range.
If your external counting circuit have some trouble with the pulse generated by the board, you can consider replacing resistor R10 on the back of the board with a little value like 22kΩ or maybe 10kΩ. This ensures high current flow to the transistor making it capable to drive your external counter better.

GEIGER PULSE
Vertical: 1V/DIV
Horizontal: 200uS/DIV

A single pulse result into a negative pulse of 5V amplitude with 200uS~ lenght

BACKGROUND OUTPUT NOISE
Vertical: 100mV/DIV
Horizontal: 20uS/Div

This is the Arduino interrupt routine for catching such pulse; "pulse_count" is the global variable that increment at each pulse. A software timer reset it each 60 seconds.
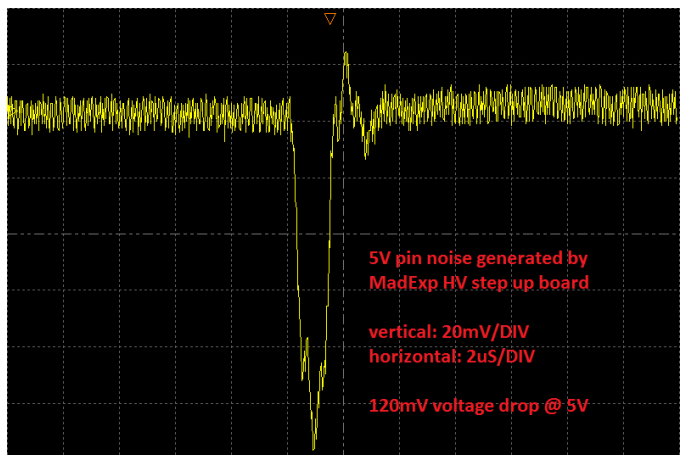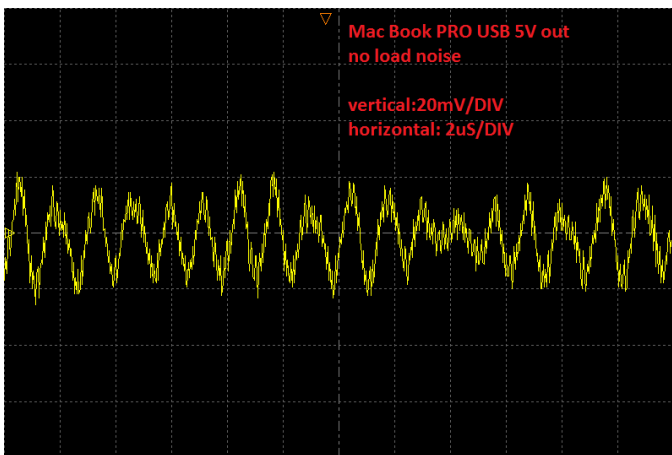
```
void setup() {
  pinMode(interruptPin, INPUT);
  attachInterrupt(digitalPinToInterrupt(interruptPin), countPulse, FALLING);
}

void countPulse()
{
  detachInterrupt(interruptPin);
  pulse_count++;
  attachInterrupt(digitalPinToInterrupt(interruptPin), countPulse, FALLING);
}
```

➢ GND power, supplies main ground, it is pin number 2. Logic and supply grounds are in common: simply there is only one ground.

➢ +5Vcc input pin number 3 is the power supply input pin. You'll feed the board connecting your power supply to it (and GND too). The board is not protected by polarity inversion. There is no voltage regulator on the board, so you simply must provide on this pin 5V. Not more, not less.

Mac Book PRO USB 5V out no load noise

vertical:20mV/DIV
horizontal: 2uS/DIV

5V pin noise generated by MadExp HV step up board

vertical: 20mV/DIV
horizontal: 2uS/DIV

120mV voltage drop @ 5V

- The 4-bit parallel interface could be attached directly to an Arduino board or Raspberry or custom board. Please note that the interface is active low. Logic "true" or "1" is pin short to ground. Logic "false" or "0" is pin left floating. Floating equals 0 because the onboard MCU have some low current pull-up resistors active on the interface. They tight each pin to +5V.

- ACK pin is connected to Atmega328 ADC6 or as per Arduino, A6 analog ADC input. It is configured as digital output active high that signals when the converter reach the selected output voltage. Could be configured, changing firmware, as analog input. You can use it, for example, as analog input to sample a battery voltage.
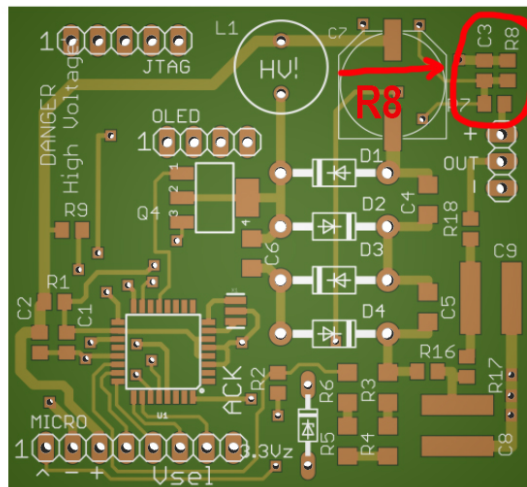
R8 resistor position 1

FIRST POWER UP

Follow this brief list to power up the board for the first time.

You'll need:
- ➢ Soldering iron with some solder
- ➢ A 5Vcc power supply
- ➢ A Geiger tube

Let's start:

1. Choose the needed voltage for your Geiger tube. For example, the SBM20 need 400V.
   By the table in the section "Voltage selection jumpers" you know that you must make a solder
   bridge on jumper number 2 to select that output voltage. Make it, but, take care to not overheat
   the board. Pay attention to not make short circuits between adjacent jumper pads.

2. Connect the Geiger tube and take care to respect your tube's polarity
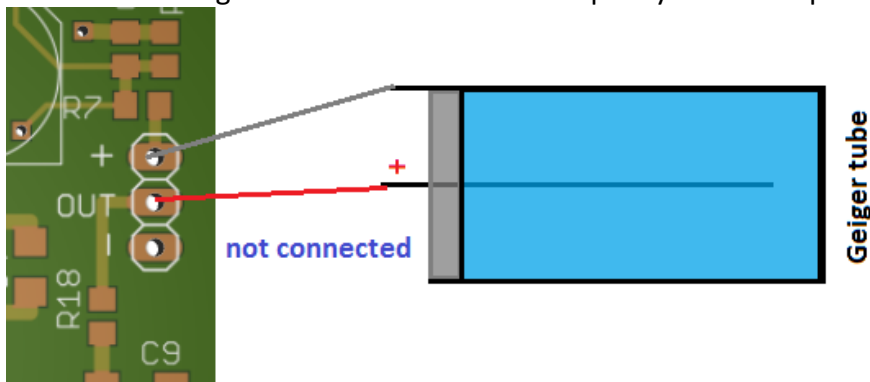
3. Connect your power supply to 5V pin and GND pin. Pay attention to do not reverse polarity.
4. If everything is ok the display must show a logo then the firmware starts rising up output voltage
   and counting up incoming pulses from the tube.
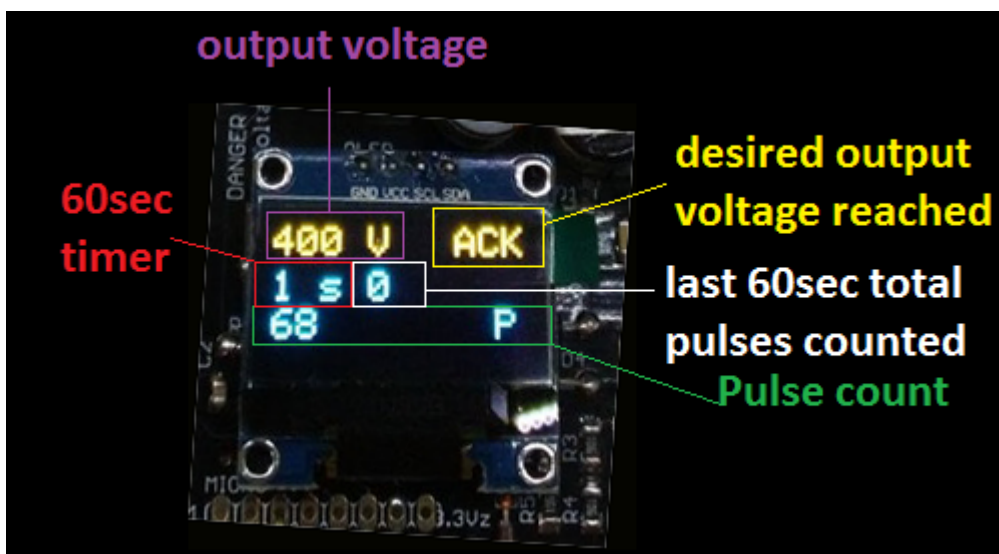
CUSTOM FIRMWARE INFO

The firmware of Madexp HV board is provided as Open Source software. You can modify it using Arduino IDE 1.8.3
To program the board with a USBisp/USBasp or other ATmega compatible programmer, you must follow this connection diagram:

JTAG connector on the board
       1: GND
       2: /Reset
       3: SCK
       4: MISO
       5: MOSI

You can create the binary file to be flashed directly on Arduino IDE.

Board setup for the IDE:

Tools→Board→Arduino Nano
Tools→Processor→ATmega328

Then you can create the firmware with:

Sketch→Export compiled binary

You'll find your *.hex file into your Arduino project folder.
The "without bootloader" has to be flashed on the IC with a software like "eXtreme Burner AVR". It is free, search online.

You can also directly program the board from Arduino IDE too.
Select your programming JTAG adapter from:

Tools→Programmer: and select yours (mine is USP-Asp)

To burn it just press:

Sketch→Uploading using programmer

That's all. Enjoy!

NOTE: FUSE BITS

The MadExp HV board comes to you already programmed but, in the uncommon case that there is the need to re-upload fuse bits configuration, here you can find more info about the correct fuse bits settings. Preamble: I've found that I must change ATmega328 fuse bits because, as it exits from factory it's configured with the option "low speed internal oscillator" active. This is wrong! MadExp HV uses external high speed crystal resonator.
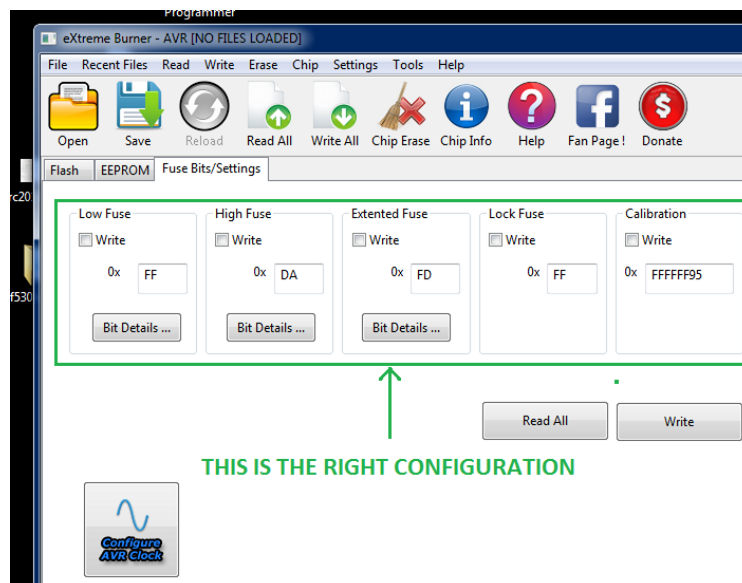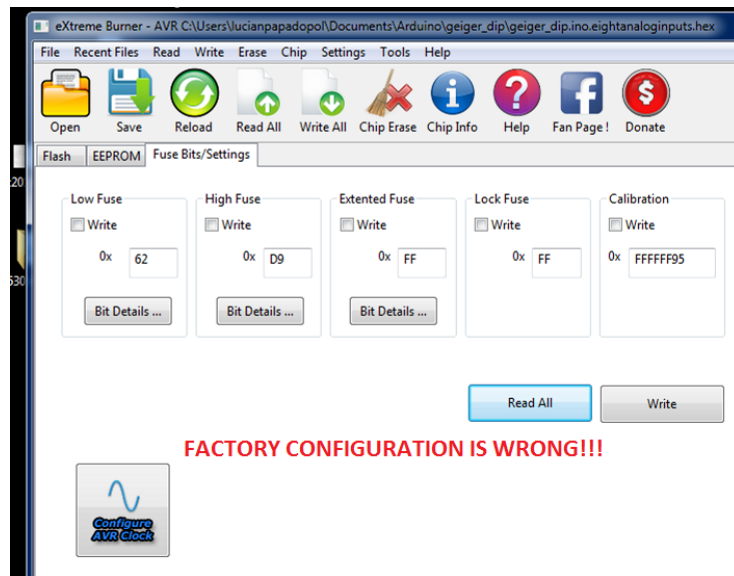
A simple but less correct way than change fuse bits manually is, from Arduino software select Tools→Burn Bootloader This will correct the fuse bits but you'll put also a useless bootloader into the chip.
Correct fuse bits are Low Fuse: 0xFF High Fuse: DA Extended fuse: FD Lock fuse: FF Calibration: really doesn't matter so much.

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For any trouble or question or if you need any help, please contact me at l.i.papadopol@gmail.com

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Warranty is provided mainly against un-proper components/parts used in manufacture of the product such the product does not work properly or un-proper assembling or manufacturing defects.

Also warranty is provided for damage occurred during shipping. In this case customers must contact MadExp.com within 48 hours after receiving the parcel or else the warranty will be void.

MadExp.com is not responsible for improper installation or users carelessness while handling the products.

How do I claim warranty for the products?

First, I recommend you to go through all documentation provided by MadExp.com for the product and check that you are using it correctly. In case that the problem still persists, please send an email with description of testing procedure that you have applied and the results to our email id
l.i.papadopol@gmail.com
Most probably the problem will be solved.

Please do not claim warranty until you are very sure that the product is faulty.

If there is any visible problem with the product, please send me a photograph of the defect and I will send replacement free of cost (in case I'm convinced that the product is to be replaced under warranty).
If there is any functional problem the customer will need to return the product back to me for testing.
 Shipping charges for returning the product is responsibility of the customer. In order to ship the product back to me, first you must contact me via e-mail and explain what the problems. Ship the product in the original plastic enclosure; it's made to protect it.
 In case of genuine fault of the product, it will be replaced at the earliest time and shipped back to you free of cost (including shipping cost).
In case there are no problems, or warranty terms are void, MadExp.com can ask customer to pay shipping charges for returning the product.
In case the warranty is void due to some reason and the product is not damaged permanently, I can repair it for free and ask customers to pay shipping charges for returning the product.
 Warranty can be claimed only once per order.

My product is out of warranty but not working somehow, can MadExp.com repair my product?

Yes, for sure. If the warranty is over it doesn't mean that my responsibility towards the sold product is over. I provide repairing service at repairing parts cost plus the shipping. Customer needs to communicate by email first before sending the product.
For any questions or suggestions please feel free to contact me.

Schematic

MADEXP
Universal HV supply
V2.5
www.madexp.com

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www.madexp.com
Under GPL v3 License
Read LICENCE file included with this
package

R1 jumper is for servicing.
Unsolder it and you can power the CPU separately from the switching section.

Pinout sense is inverse on PCB's serigraphy.
1 is 5, 2 is 4.

10M is 1206 package 500V insulation
others are 0805

+5V
C2
105
GND
R1
Jump104
R9
4.7K
GND
C1
104
GND
X1

ATMEGA328P_TQFP
U1
AGND
GND
PB7(XTAL1/TOSC1)
AVCC
VCC
AREF
PC6(RESET)
PB6(XTAL2/TOSC2)
PD0(RXD)
PD1(TXD)
PD2(INT0)
PD3(INT1)
PD4(XCK/T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1A)
PB2(SS/OC1B)
PB3(MOSI/OC2)
PB4(MISO)
PB5(SCK)
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4/SDA)
PC5(ADC5/SCL)
ADC6
ADC7
GND

0.96" OLED 128x64 banggood type
OLED

JTAG

NOT CAPS BUT JUMPERS

MICRO

GND
+5V
C7
1000uF
L1
3.3mH
caps are low ESR <1 ohm
inductors are low ohm too <3 ohm

D1
RGP02
GND
800V mosfet
Q4
BSP300
D2
RGP02
C4
4.7n
GND
SEZIONE CONVERTITORE HT
HV converter
C6
4.7n
D3
RGP02
C5 4.7n
Caps are 1-1.5kv rated
D4
RGP02

R2
100k
R6
10M
10M
R5
R4
10M
10M
R3
GND
10x10M
R16
1M
SEZIONE FILTRO HT
HV ripple filter
GND
C8
47nF
1M
R17
GND
C9
47nF
10M
R18
Caps are 1.5/2KV rated
OUT

Q1
BC847
R10
100k
+5V
GND
GND

R8
100k
R7
10K
GND
C3
47pF
D5
3.3Vz
R8 is 100K for 450V
22K for 600...700V
10K for 900...950V
GND