

LED Guard DC

Hard- and software description

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# Hardware

## Version 1.1

* Alarm relay P and NC have to be swapped

## Improvements for V1.2

* ~~Kijken of alle NC's aan GND kunnen~~
* ~~Recommended capacitors toevoegen aan buck converters en ontkoppeling bij alle IC's~~
* ~~Een andere stroomsensor met minder maximale stroom voor preciezere metingen~~
* ~~Meer EEPROM!~~
* ~~Meer programma opslag~~
* ~~Serial monitor support~~
* ~~Met relay voor 0-10V doorverbinding bij printje spanningsloos~~
* ~~Alleen zelf 0-10V uitsturen bij calibratie, anders via relay vanaf klimaatcomputer laten lopen~~
* ~~Preciezere 0-10V uitsturing (eigenlijk niet nodig, omdat deze alleen tijdens calibratie gebruikt wordt)~~
* ~~Ook uitgestuurde 0-10V terug kunnen meten~~
* ~~Een Mosfet (~~[~~voorbeeld~~](https://nl.mouser.com/datasheet/2/196/Infineon_IPD038N06NF2S_DataSheet_v02_01_EN-3083458.pdf)~~) in serie met de relay, zorgt ervoor dat in geval van kortsluiting het alsnog uitgeschakeld kan worden, met een relay is dat maar de vraag. Wel met zo laag mogelijke Rdson om spanningsverlies te voorkomen. Wordt toch lasting ivm handschakelaar aan de positieve zijde en mosfet aan de negatieve zijde.~~
* ~~Optie voor altijd voeden via externe 6.5-72V (12-48V is ook prima wss) voeding in geval dat de trafo bij lage percentages niet boven de 6.5V uitkomt. Dipswitch kiezen tussen vaste voeding en voeding via trafo.~~
* ~~Genoeg afstand tussen trough hole gaten en de din rail connector.~~
* ~~Change 10V to 12V on top overlay text~~
* ~~PWM input voltage (measure with oscilloscope) (The dimming is not performed by PWM, but by Constant Voltage)~~
* ~~ESD protective (not fully implemented)~~
* Switch large solder pads problem
* ~~Check EEPROM~~
* ~~HW version detection~~

## Version 1.2

### MCU

* [Digikey selection](https://www.digikey.nl/nl/products/filter/ingebouwd/microcontrollers/685?s=N4IgjCBcoGwJxVAYygMwIYBsDOBTANCAPZQDaIALAAxwDMdIh1cFtVIAuoQA4AuUIAMq8ATgEsAdgHMQAX0JgArIsQgUkDDgLEy4KgA4qAJnYLFFGAHYEZi4cbh9%2B6kYdgn1GA6NHF%2By66EPn6WtN6%2B-ipBigH6gSC%2BcIq0%2Bt4wShQUaRmpQTAptBBB-r5RIGy0RvQOFUbUDvowilSmII3N8e1UXoRw3Yo9IEmKcEXg7s2DStZwlm5%2BLfFgcLNgrVV0tGXwlrtjdSP1QZb%2BYGNgJopKDhR1uw7KlWEKMHH%2BblXKNuCF1uvGYHy4RO%2BjKJgsRjGljAln6aVe7gc0NhVm8LHouRAyO6mNYdTOnB4-EgQlEkhk8gS%2BjC0DUaCweEIJEg5FoFBiYCyhC2cHg7C4ID4AmE4mkciCo1U6k0jJ0LPAJiMMC5IGUPnOrxomMVVAo%2ByMuyqwICKsh1AJeSsVDmEtuPga0LYbgMVGuCic9DKy3cmWyyTBTV%2BNSoT0Gu2GDWVSTcE2Mbgo1L18xmz0coSTChWsJtbV8MBahMFxNJoopCjOrlp0oZ2mZ5GagPsTCuNG8NBY%2BwM8G%2BJhgVVNRn89wUliaoSRMO63xhTXgblHavnrBOS8hXuhI2njrdCWM%2Bl5bcHK6Ce-HClo0KoXtoO2vFBYObAbLo08qBqWFWtHziQIUBvRHzWLcgEsK0Fz%2BH0bh8t0DjpLQbIPNSnKIeqDwnCYDxJPuNx9BchZCiSIrkuK4BwNhVb0loTK6PylI%2BAYqgESAAAiRAAK4AEaYLgDgALaSAISokQAtJWyBQKIbG1roKgcLIlJeLSYgACYCMJaxjExDgAI68AAngIYz6dwPEkug2AoPJQA)
* Working voltage should be 5V
* Crystal oscillator intern

#### EEPROM

Minimum EEPROM 1kB:

* 200 bytes for saving current calibration values
* 200 bytes for saving voltage calibration values
* 50 for some extra savings
* \*2 for future assurance

#### IO

Minimum IO 26:

* 16 (also were available at V1.1)
* 1 MOSFET
* 1 extra relay (for 0-10V)
* 4? extra for serial monitor support?
* Minimum 4 extra for future assurance

#### Flash

Minimum 8 times of V1.1 flash, so 2k \* 8 = 16kB at least

#### The MCU

[User’s Manual: Hardware](https://www.renesas.com/us/en/document/man/rl78g23-users-manual-hardware?r=1496636)

[Digikey: R7F100GGF2DFB#AA0](https://www.digikey.nl/nl/products/detail/renesas-electronics-corporation/R7F100GGF2DFB-AA0/18163228)

48-pin plastic LFQFP

(7 × 7 mm, 0.50-mm pitch)

### DAC

DAC does not have to be very precise, 100 points from 0 to 10V is acceptable.

MCU internal DAC is preferred, saves money

### Current sensor

Max current to measure?

### Small signal relays

* 1 relay for alarm contact
* 1 relay for 0-10V connection selection
* Coil voltage 5V
* J104D2C5VDC.20S is cheapest and already used in V1.1, J104D2C5VDC.15S is same price but lower power consumption so better, but not required to be changed

### Program header

Figure 1 shows the official program header in the Altium schematic, another header is chosen because of the size of the official header. Besides that, the chosen header supports UART <-> USB communication.

Afbeelding met tekst, schermopname, diagram, Lettertype

Automatisch gegenereerde beschrijving

Figure Official Renesas program header design

# Software

## Version 1.1

### ATtiny

[ATTINY261A-MN Datasheet](https://ww1.microchip.com/downloads/en/DeviceDoc/doc8197.pdf)

### Button

Inversed



### Percentage slide switch

|  |  |  |  |
| --- | --- | --- | --- |
| Percentage | Output voltage | ADC value | ADC range |
| 5 | 5 | 1023 | >800 |
| 10 | 1.667 | 341 | >200, <400 |
| 15 | 2.5 | 511 | >440, <700 |
| 20 | 0 | 0 | <150 |

#### Debug



### Vin

|  |  |
| --- | --- |
| Vin | ADC |
| 12 | 223.2 |
| 24 | 446.4 |
| 48 | 892.8 |

#### Debug



### Potentiometer

Pot all the way to the right gives 0V

Pot all the way to the left gives 5V

When the calibration starts, the maximum output voltage is determined based on the potentiometer



### Relay + Hand/Auto switch

#### Debug



### AQ

116 gives 10V, so range from 0..10V = 0..116.

The output voltage can be regulated by the potentiometer, input voltage should always be 0..10V independent from the potentiometer.



#### Debug



### Current sensor

Range: –9 A → 86 A

Zero current output voltage = 0.5V

50 mV/A with a 10-bit ADC (4.89 mV/step) means ~0.1 A/step

### AI

Analog 0-10V input. 10k/1k voltage divider. 1023 steps over 5V.

186 steps 0..10V (0..186)

### EEPROM

EEPROM size is 128 bytes

The calibration values are saved in EEPROM for every 2nd AQ value (0, 2, 4, ...)

|  |  |  |
| --- | --- | --- |
| Bytes count | Content | Description |
| 2 | MaxCurrent | The current during calibration at maxOutputVoltage (0..1023) |
| 2 | MaxVoltage | The voltage during calibration at maxOutputVoltage (0..1023) |
| 1 | MaxOutputVoltage | Count = MaxOutputVoltage / 2; |
| 60 | Current[Count] | Calibration currents (based on output voltage) (Scaled from 0..1023 to 0..MaxCurrent) |
| 60 | Voltage[Count] | Calibration voltages (based on output voltage) (Scaled from 0..1023 to 0..MaxVoltage) |

### Calibration

Calibration steps:

1. Determine Maximum values (writing MAXAQ and reading current, voltage)
2. Determine all other values and save them to the EEPROM

### Improvements V1.2

* Possible switch on/off detection at startup??

## V1.2

[Hardware manual](https://www.renesas.com/en/document/man/rl78g23-users-manual-hardware?r=1496636)

[Digikey](https://www.digikey.nl/en/products/detail/renesas-electronics-corporation/R7F100GGF2DFB-AA0/18163228?s=N4IgTCBcDaIEoHYBiBGADGg4ppYAiSAQgMQCCpaIAugL5A)

### E2 Lite

[E2 Lite connections](https://www.renesas.com/en/document/mat/e1e20e2-emulator-e2-emulator-lite-additional-document-users-manual-notes-connection-rl78?srsltid=AfmBOoob1ZQkhzkdPwRpSwyRUm1aJqw1OeFgj8v20R3p-PA8bh2DdsLf)

A diagram of a connector

Description automatically generated

A close-up of a document

Description automatically generated

### Button, LEDs

      bool buttonState = !PIN\_READ(I\_BUTTON);

PIN\_WRITE(Q\_LED1) = 1;

PIN\_WRITE(Q\_LED2) = 0;

PIN\_WRITE(Q\_LED3) = 0;

### Flash

[Example](https://www.renesas.com/en/document/apn/rl78-family-renesas-flash-driver-rl78-type-01-sc-version-data-flash-application-note), references often to [this manual](https://www.renesas.com/en/document/man/renesas-flash-driver-rl78-type-01-users-manual-rl78g23) and [this manual](https://www.renesas.com/en/document/man/renesas-flash-driver-rl78-type-01-users-manual-rl78g23?r=488896)

#### Memory format

* The flash is 8 kB.
* ADC is 12-bit
* DAC is 8-bit
* DAC\_MAX = 231 (10.03 V)

Calibration values: We send out 0-255 (8-bit), at which 2 12-bit measurement is done. (12-bit is stored as 16-bit). We measure output current, output voltage and input voltage.

This makes 2 \* 3 \* 232 = 1392 bytes to be stored for calibration

So we save the following

* uC\_ANI6\_AI (16-bit)
* uC\_ANI7\_VIN (16-bit)
* uC\_ANI4\_CURRENT (16-bit)

When erasing 1 block, 256 bytes are erased, so 1392/256 = 6 blocks should be erased.

#define DAC\_MAX (231) // 10.03 V

struct calibrationValue

{

    uint16\_t AI;

    uint16\_t current;

    uint16\_t voltage;

};

calibrationValue calibrationValues[DAC\_MAX + 1];

### Fault detection

There is an integrator used for fault detection

For now lets assume the user sets the switch to 10%

The integrator start counting when the current goes over/under the calibrated value +/- 10%. But for smaller currents, the value is too low to be accurate when using only the percentual error, so a fixed error of 0.1A is added (10 ADC points). So the threshold is +/- (10% + 0.1A).

The trip delay is 10 seconds

The trip value of the integrator = the threshold + 5% (fixed) of the calibrated value

### Percentage slide switch

This version is times 4 the earlier version because this is 12-bit instead of 10-bit (table is of earlier version).

|  |  |  |  |
| --- | --- | --- | --- |
| Percentage | Output voltage | ADC value | ADC range |
| 5 | 5 | 1023 | >800 |
| 10 | 1.667 | 341 | >200, <400 |
| 15 | 2.5 | 511 | >440, <700 |
| 20 | 0 | 0 | <150 |