

SMDKing

EMP-Detector V2.5



- DEVICE** : EMP Detector V2.5
- FEATURES** : Detecting high energy pulses
- APPLICATIONS** : Detecting lightning and other types of high energy discharges
- QUICKGUIDE** : For pin-connections, check page 4

INDEX

INFO	3
SPECIFICATIONS	3
PINNING	4
LED-indicators at PCB	5
Power LED	5
EMP LED	5
EXPLAINING "DIGITAL OUT"	6
BATTERY OPERATED SENSOR	7
CR2032 (3V)	7
Li-Ion	8
AA / AAA	8
SCHEMATICS	9
Battery operated	9
Delayed Signal	9
Stretched signal	9
Control a piezo buzzer	10
Control a relay	10

INFO

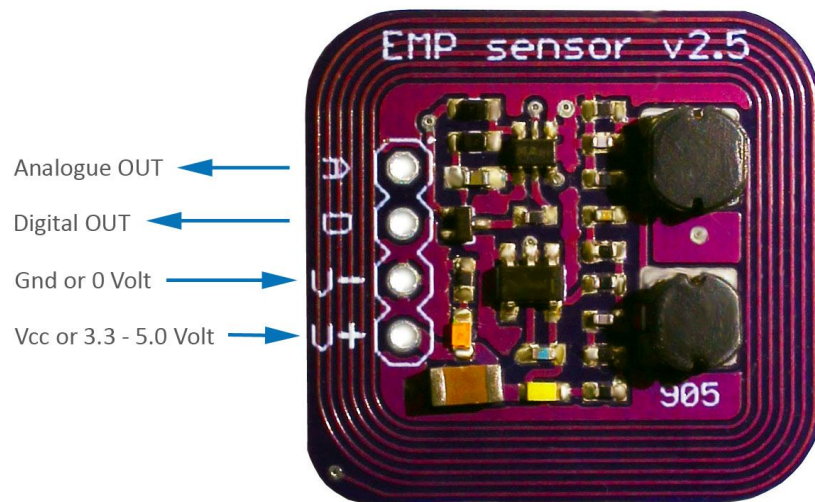
After thorough research and testing SMDking, presents a new lightning detector sensor also known as an EMP-sensor. EMPs (Electro Magnetic Pulse) are signals which occur when lightning takes place. This sensor can be used for a variety of usage :

- **Outdoor events**
Early warning system for any outdoor sports, like golf, football, soccer, hockey, tennis etc.
- **Photography**
The sublime way to catch a lightning-event by camera, when triggered by this EMP-detector. It can also be used as a trigger for other events, like activating multiple flash-lights.
- **Scientific experiments**
Detecting EMP's for analysis-purposes, like locating the impact of lightning by multiple sensors, or figuring out how lightning works. These sensors are also used in aerospace, nuclear research centers, road construction, oil-business and telecommunication industry.
- **Arduino experiments**
For the hobbyists who are interested in weather-conditions or detecting other types of EMP-sources.
- **Weather stations**
Next to rain,- barometric,- temperature,- moisture-sensors, a lightning detector can be included.

SPECIFICATIONS

Operating Voltage	: 3.0V to 5.0V DC
Operating Current	: 3.5 mA to 22 mA at 5V DC 0.9 mA to 4.3 mA at 3.3 V DC 0.6 mA to 3.7 mA at 3.0 V DC
Dimensions	: 22.5 x 23.5 x 4.0 mm / 0.89 x 0.93 x 0.16 inch (W x L x H)
Weight	: 1.2 gram / 0.04 ounce
Pins	: 4
Pinning	: A = Analog output D = Digital inverted output (sourcing upto 12.5 mA at Vcc) V- = Gnd or 0V V+ = Vcc
Detection range	: Lightning upto 22 km / 15 miles distance
RoHS	: Yes

PINNING



- V+ V- : To activate the sensor, [V+] and [V-] need to be connected to a powersource. The powersource should be at least 3.0 V DC and max. 5.0 V DC. The EMP-detector is running low power (3.5 mA), when no lightning is detected. When lightning is detected, the detector requires a pulse of 22 mA when powered at 5 V DC.
- D : This pin can be used as a trigger-function for high energy EMP's. When no or low activity is detected the pin will remain 0 Volts. When detecting a strong signal at pin A, it will trigger this D-pin to Vcc-level.
- A : Analogue output. When no EMP is detected, this pin is held at Vcc level. When a high energy EMP is detected, the signal will drop significantly to 0 Volts.

LED-indicators at PCB

PowerLED

This LED (purple light) is active, when Vcc and GND are connected to a powersource of at least 3.3 Volts DC. This LED is located right above the V+ pin.

Flash-LED

When a high energy EMP is detected a white LED will blink shortly. This LED is located close to the powerLED.

Location of indicator LEDs



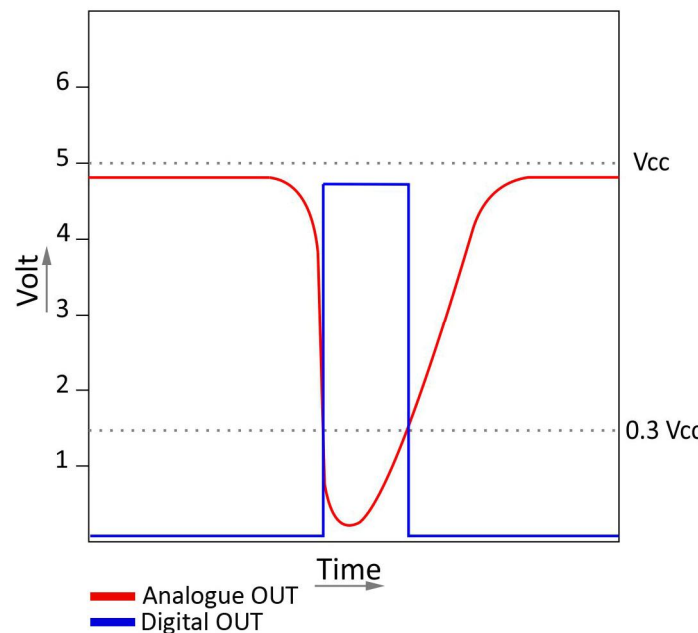
Power LED (purple)



Flash LED (white)

EXPLAINING "DIGITAL OUT"

The image below shows how the Digital OUT is operating, based upon Analogue OUT.



When no EMP is detected, the Analogue OUT is at (nearly) V_{cc} level. At this status, Digital OUT will be (nearly) 0 Volts. As soon as a strong EMP is detected, the Analogue OUT will sink to nearly 0 Volt. Digital OUT will be triggered, as soon as Analogue OUT is at / lower than 30% of V_{cc} . In this case : 30% of 5 Volts is 1.5 Volts.

In short :

When Analogue OUT is below 1.5 Volts, Digital OUT will rise to 5 Volts.

When Analogue OUT is above 1.5 Volts, Digital OUT will drop to 0 Volt.

Good to know

In general, Digital OUT will respond with a maximum delay of approx. **750 ns**. This is pretty fast and makes it very interesting to use it as a trigger-function to activate external electronic devices.

Digital OUT can source upto 14 mA.


BATTERY OPERATED SENSOR

This sensor can be battery operated. You can use several types of batteries, like coin-cells, rechargeable Li-Ion batteries and even by pairs of AA or AAA batteries. It's important the total Voltage will be 3.0 Volts or higher, but not exceeding 5 V DC. To calculate the estimated time the sensor will operate, the capacity of a battery is of importance.

CR2032

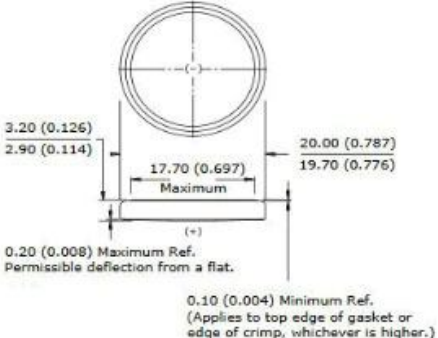
As an example, let us assume you plan to use a CR2032 3V Lithium coin-cell (brand : Energizer). Below is a part of the datasheet for this cell :

ENERGIZER CR2032



Industry Standard Dimensions

mm (inches)



3.20 (0.126)
2.90 (0.114)

17.70 (0.697)
Maximum

20.00 (0.787)
19.70 (0.776)

0.20 (0.008) Maximum Ref.
Permissible deflection from a flat.

0.10 (0.004) Minimum Ref.
(Applies to top edge of gasket or
edge of crimp, whichever is higher.)

Lithium Coin

Specifications

Classification: "Lithium Coin"
Chemical System: Lithium / Manganese Dioxide (Li/MnO₂)
Designation: ANSI / NEDA-5004LC, IEC-CR2032
Nominal Voltage: 3.0 Volts
Typical Capacity: 235 mAh (to 2.0 volts)
(Rated at 15K ohms at 21°C)
Typical Weight: 3.0 grams (0.10 oz.)
Typical Volume: 1.0 cubic centimeters (0.06 cubic inch)
Max Rev Charge: 1 microampere
Energy Density: 198 milliwatt hr/g, 653 milliwatt hr/cc
Typical Li Content: 0.109 grams (0.0038 oz.)
Operating Temp: -30C to 60C
Self Discharge: ~1% / year

Safety:

⚠ WARNING

(1) KEEP OUT OF REACH OF CHILDREN. Swallowing may lead to serious injury or death in as little as 2 hours due to chemical burns and potential perforation of the esophagus. **Immediately see doctor; have doctor phone (800) 498-8666.**

(2) Battery compartment design. To prevent children from removing batteries, battery compartments should be designed with one of the following methods: a) a tool such as screwdriver or coin is

The typical capacity for this battery is rated as 235 mAh at 2 Volts (red marked area). This means, it can source 235mA during 1 hour.

The EMP-sensor requires 0.9 mA when operating at 3.3 Volts.

The datasheet shows this specific CR2032 battery has a capacity of 235 mAh.

So, how long will the sensor run at such battery ?

For hours : $235\text{mAh} / 0.9 \text{ mA} = 261 \text{ hours (approx)}$.

For days : $261 \text{ hours} / 24 \text{ hours per day} = 10.88 \text{ days}$ or roughly 10 days and 21 hours.

Important note : The datasheet shows also the battery will drop in Voltage from 3.3 Volts (full) to 2.0 Volts (dead). The EMP sensor is still operating at 3.0 Volts. This means the Voltage of the CR2032 will drop below 3.0 Volts at a certain time, while the sensor needs at least 3.0 Volts. The datasheet is not providing any info about this, which turns above calculation into an estimate. It's very likely the sensor will likely stop operating a bit earlier than calculated.

Rechargeable Li-Ion

The sensor can also be powered by a re-chargeable Li-ion battery. They're rated as 3.7V DC. This actually means they're 4.15 Volts (full) and 3.0 Volts (nearly empty). Both values are acceptable for the sensor to operate. Assume you use a 400 mAh re-chargeable Li-Ion.

A brief calculation will give an impression about endurance :
Hours (minimum) : $400 \text{ mAh} / 0.9 \text{ mA} = 444.4$ hours which is approx. 18 days and 12 hours.



AA / AAA

These are very common batteries and contain a large capacity. The capacity of such battery varies between 900 mAh for AAA upto 2600 mAh for AA's (at moment of writing). It's easy to understand how powerful these batteries are. They're guaranteed to let an EMP-sensor operate for a lot of days.



Notes :

Differences in current

You might wonder what is causing the relative huge difference in current consumption, while powering the sensor at 5 V DC (**SPECIFICATIONS**). The given values are 3.5 mA for idle-status versus 22 mA when detecting an EMP.

You are fully correct about this. However, in general an EMP from lightning is a milli-second "event". This means the EMP will draw for a few milli-seconds the given maximum rated current. Only during this milli-second event of detected EMP, the given maximum current is drawn. This will have a minimum effect for the battery. By this, you're correct the battery will last less hours as calculated. Therefore, it is to emphasize the calculated values are theoretical values.

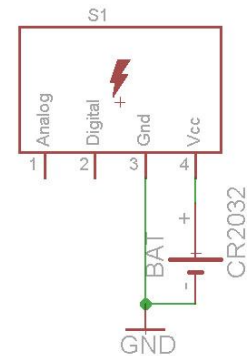
Extreme low idle-mode

The powerLED is mainly responsible for the current, drawn at idle-status. If this LED is not present, current in idle-mode will be drastically lowered, like in micro Amperes range.

SCHEMATICS

Battery operated

To get the EMP-sensor battery operated, it requires a minimum of components: only the battery. In this schematic, it's powered by a CR2032 battery. This battery can be replaced by any single cell Li-Ion, 2x AA (in series) or even 2x AAA (in series). Just keep in mind the polarity of the battery.



There are ofcourse more options. The following schematics are based upon a Vcc of 5V DC. This can be a powersupply, poweradpter (*), powerpin from an Arduino, or whatever.

(*) For an poweradpter it is important the output Voltage is clean and smooth. This means, not much ripple in Voltage. If there's too much ripple or the poweradpter is not stable enough, it might trigger the sensor itself. The following examples are very often used and operate in a reliable manner. For all schematics, a 100 nF decoupling capacitor between Vcc and ground is advised, but not required. This is the reason why it's not used in those schematics.

Delayed signal

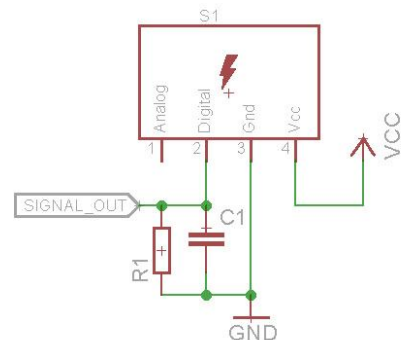
To delay the "Digital OUT"-signal, a combined use of a capacitor + resistor is suggested. The time to calculate the desired effect, the following formula can be used :

$$T = R \times C.$$

T is time in seconds

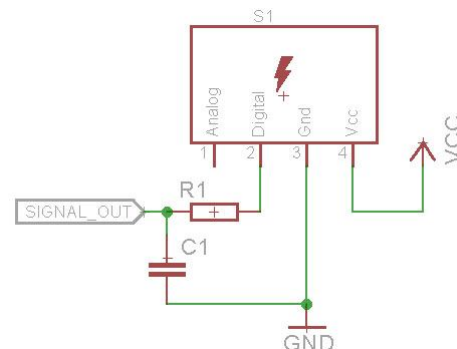
R is the resistance in Ohms

C is the capacitance in Farads and.



Stretched signal

To stretch the "Digital OUT"-signal, again, using a capacitor + resistor can manage the job. However, this time, resistor and capacitor are placed in a different configuration.

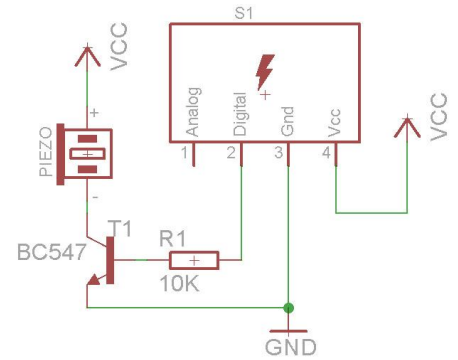


Control a piezo buzzer

There are 2 versions of piezo buzzers : passive and active.

The difference is in the type of sound they generate.

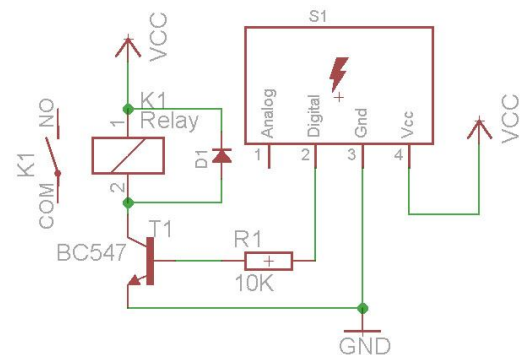
Whenever a passive piezo gets powered, a single "ticking" noise will be generated. However, an active piezo buzzer will generate a continuous beeping sound as long as it is powered. Mostly the generated sound is between 2 and 3 KHz. Since an EMP is a short enduring event, it's advised to use an active piezo buzzer.



Control a relay

Whenever devices, which operate at higher Voltages, the use of a relay is advised. There is a huge variety of relays available. Whenever you look for an relay, there are 3 parameters of importance :

- Nominal (Coil) Voltage
This refers to the Voltage which requires the internal coil to guarantee the relay will switch.
- Operate Voltage
This is the minimum Voltage for the internal coil. This coil get's magnetic and will get the relay to "make a switch".
- Switching Voltage
This is displayed as AC and / or DC Voltage. This value shows at what maximum Voltage an external device can operate.



Notes :

1. It is important to get a datasheet for the used / planned relay. Or get at least info about these specific parameters.
2. Some relays use polarity. This means it's important to know how the internal coil (or pins) should be connected. In case, reversed polarity is involved, you might hear a ticking sound, while it doesn't mean it's actually switching.

Written by : SMDKing
Datasheet : EMP detector / sensor V2.5
Version : 1.0
Date of release : 4th of may, 2023
Copyright : ©2023, all rights reserved

Information finished by SMDKing is believed to be accurate and reliable. However, no responsibility is assumed by SMDKing for its use, nor any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice.