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# 1 Introduction

This document explains why the usage of isolated amplifiers is highly recommended, in order to get reliable measurement results and save your instrument from eventual damage.

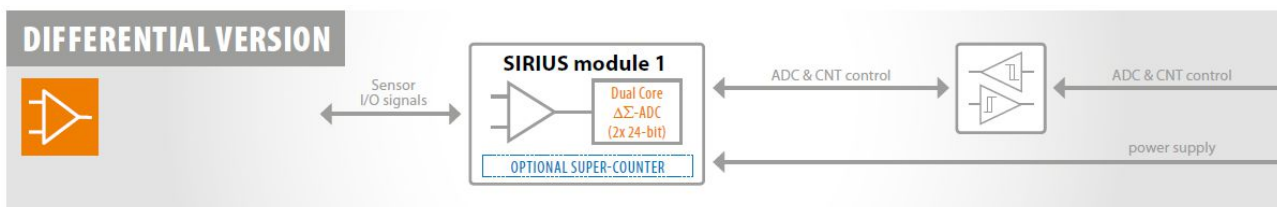
## 1.1 Amplifier technologies

### 1.1.1 Single-ended amplifier

The architecture of the single-ended amplifier is very simple, and therefore cheap. It only makes sense in battery-powered voltmeters (floating source), because there is no connection to the ground of any other equipment. The significance of this amplifier in the precision measurement segment is very small nowadays.

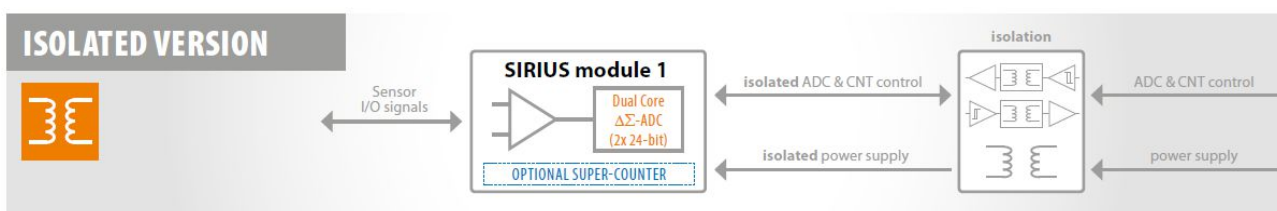
### 1.1.2 Differential amplifier

The differential amplifier cancels out the noise, which is coupled in on both inputs with the same amount (due to long sensor cabling or environmental noise), it only amplifies the difference. With this concept it is possible to avoid ground loops, but only if the voltage on each line stays inside the common mode voltage.



### 1.1.3 Isolated amplifier

The “worry-free solution” provides isolation and the differential input at the same time. With the isolated SIRIUS*i* devices of DEWESoft, both the **sensor signal** and the **power supply** (including **sensor excitation**) are **isolated**, so it's the perfect solution with channel-to-channel and channel-to-ground isolation. It copes with differences in ground voltage up to 1000 V, which covers all industrial applications.



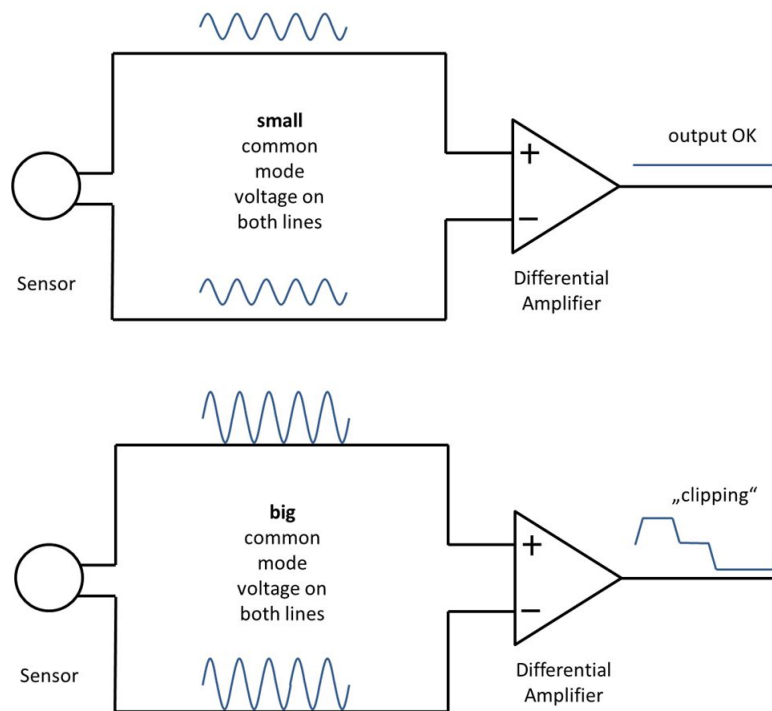
## 2 Measurement faults

### 2.1.1 Common mode voltage

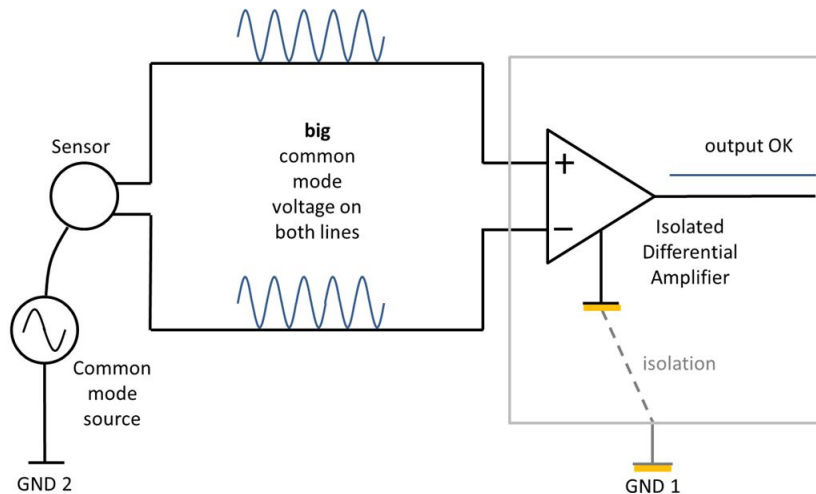
Usually the differential amplifier cancels out the noise, which is coupled in on both inputs with the same amount, it only amplifies the difference. But in contrast to isolated amplifiers, the input common mode voltage range is very limited here. So there are certain situations, where differential technology reaches its limit:

#### Thermocouple measurement (AC common mode)

When the common mode voltage amplitude exceeds the amplifier's common mode voltage input range, the amplifier starts "clipping", resulting in a distorted, unusable output signal.

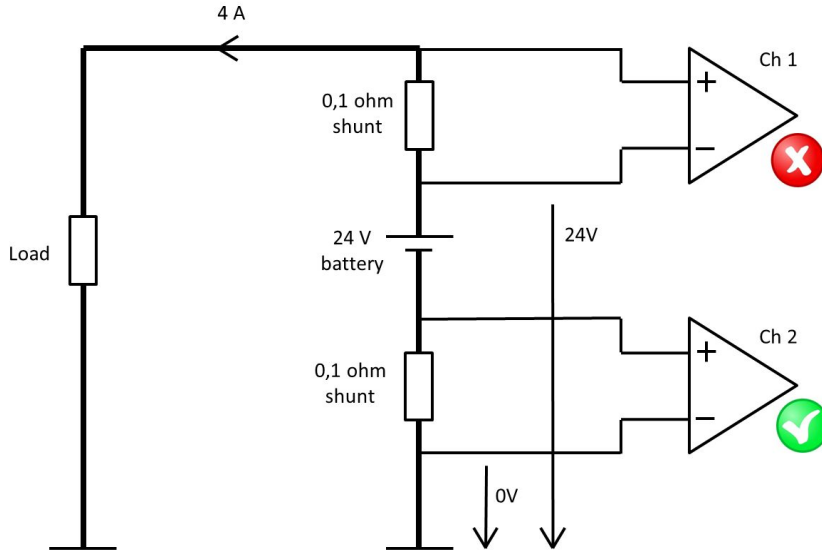


With the use of an isolated amplifier, the measurement can be done, even if there is high common mode.



**Current measurement on shunt on positive line (DC common mode)**

The measurement configuration below shows the possibilities to measure the current of a 24 V supplied system. The optimum amplifier input range in this case is 500 mV. That will work fine for Ch 1 in the picture, but not for Ch 0. This channel will exceed the maximum common mode voltage and go to overflow.



The solution would be to measure in the low-line, or use an **isolated** amplifier.

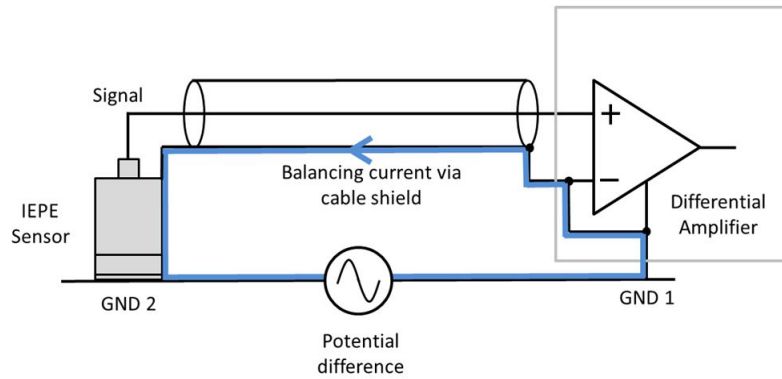
**2.1.2 Common mode rejection**

The Common Mode Rejection Ratio (CMRR) is a parameter to specify the how good an amplifier is able to suppress unwanted equal (non-differential) signals on the input. For example, if you measure a static signal, the DC common mode will affect the accuracy, while the AC common mode will result in noise.

### 2.1.3 Ground loops with sensor

In a lot of the cases the noise in the measurement data has its root cause by inducing through so-called “ground loops”. There are various ways to create them, some of them can be very harmful to the measurement instrument!

In the picture below is a typical setup: the measurement amplifier is connected to the ground (GND 1) on one side, an asymmetrical shielded cable is used to connect the sensor, which metallic housing is placed on a electrically conducting on a ground (GND 2). Due to the long distance of the cable, there is already a difference in the ground levels, which acts like a voltage source, coupling in all electromagnetic noise e.g. in industrial environment.

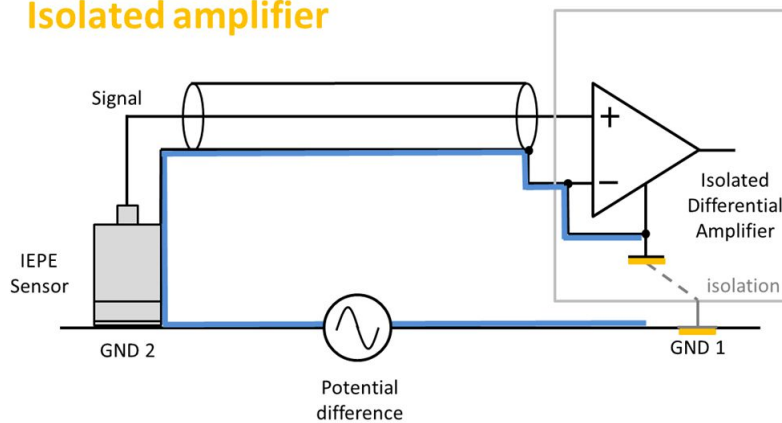


How big does the error have to be, to be significant?

That depends on the situation. For example, when connecting a Charge or IEPE sensor with a high dynamic output of 140 dB to the amplifier, which is set to 10 V input range, the allowed potential difference would be only 1  $\mu$ V!

So, the solution would be to **isolate the sensor or the amplifier.**

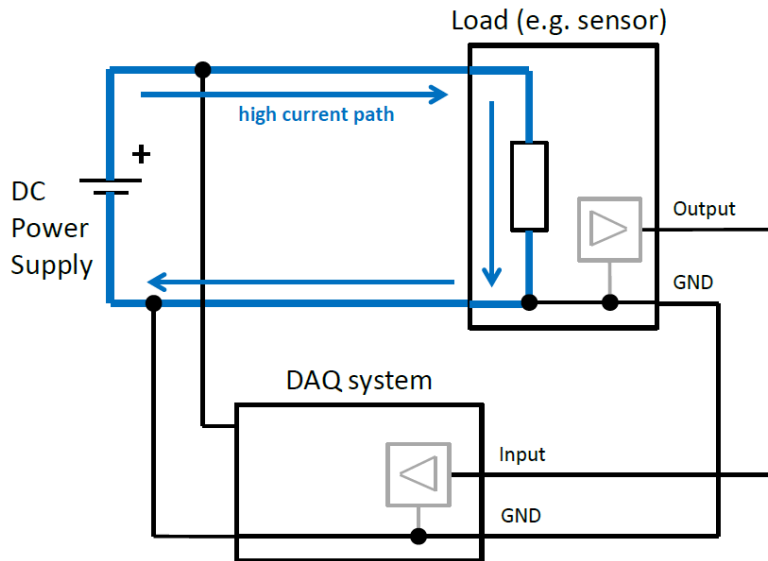
#### Isolated amplifier



## 2.1.4 Ground loops with power supply

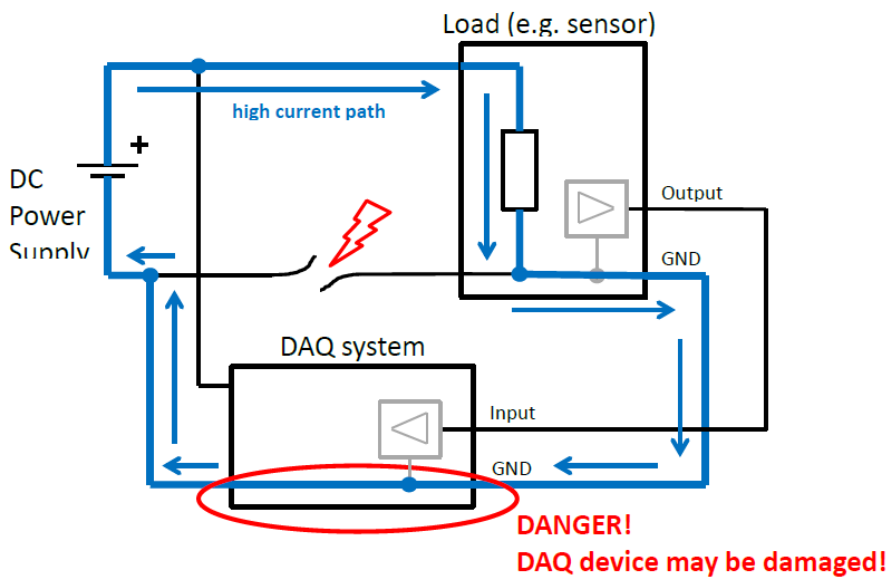
Ground loops can also be created by non-isolated power supply concepts! Care must be taken when supplying multiple devices – even if each device itself has a correct over-voltage and reverse polarity protection like the complete DAQ-System series from DEWESoft (like Sirius, DEWE-43...).

The picture below shows a typical configuration. A sensor and the DAQ-System are supplied out by the same DC power supply (e.g. the vehicle on board network). You can see the GND is connected from two points: The main current flows along the blue thick line (“high current path”), to the load and back. But the GND of both devices are also connected together, through the sensor output and DAQ input.



Error case with broken GND cable:



You can imagine what will happen when “high-current path” is open: the current will flow a different way. Now the return supply path of the sensor is routed through the GND of the sensor input from the DAQ device.



Usually the internal circuitry is not capable of driving this high current. So the DAQ device may be damaged!

With an **isolated** power concept, no error current would have been possible through the supply line.

### 3 Conclusion

-  **Isolated** (and at the same time: differential) signal conditioning: It is the more expensive, but “worry-free” solution, also an unexperienced person is able to make correct and accurate measurements.
-  **Differential** signal conditioning: This technology is cheaper, and shows no disadvantages when using isolated sensors like strain gages, current clamps, acceleration and pressure sensors. It also delivers a high quality result, but the engineer needs to know the sensor behaviour (isolated, CM range..), and needs to take care of the correct setup/cabling, to guaranty correct measurements.