APPLICATION NOTE

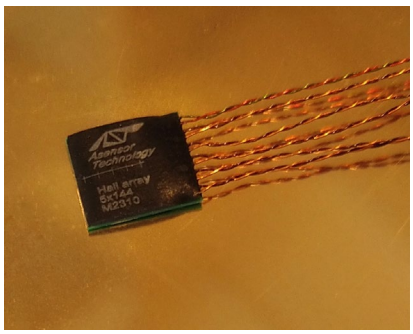
Hall sensor arrays, Series vs Individual Readout

Introduction

When multiple Hall sensors are used in one system (an array), there are two main ways to connect them:

1. All sensors in series (one shared current source)
2. Each sensor individually (separate connections, per-sensor current source)

Both approaches have advantages and limitations.



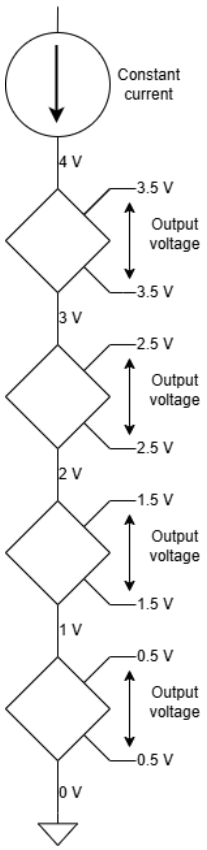
1. Series Connection (Single Current Source)

How it works

All sensors are connected one after another (in series) and powered by a single current source.

You only need:

- 2 wires for supply (shared by all sensors)
- One differential output pair per sensor



Advantage

- Less wiring
- Simple setup
- Only one precise current source required

Key limitation: common-mode voltage buildup

Each Hall sensor behaves like a balanced bridge, you could (as user) compare it with a Wheatstone bridge. Even when there is no magnetic field, both output lines sit at a certain voltage level (typically around 50% of the supply voltage).

This is called **common-mode voltage**. In the picture on the right, you can see the setup and the common mode voltage at zero magnetic field. After only a few sensors, the voltage level can already reach several volts, which may exceed the input range of standard measurement systems.

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Simple explanation

You are measuring a small difference between two signals, but both signals are sitting on top of a larger voltage.

Think of it like this:

- You want to measure a small height difference
- But everything is already placed on a tall table

The difference is still there, but your measuring system must handle the total height.

What happens in a series chain?

Each sensor adds its own common-mode voltage. Example voltages:

HE144 (1 mA, 1 kΩ)		
Number of sensors	**Total voltage across chain**	**Common-mode at output**
1	1 V	0.5 V
5	5 V	2.5 V
10	10 V	5 V
20	20 V	10 V

HE214/HE244 (2 mA, 500 Ω)		
Number of sensors	**Total voltage across chain**	**Common-mode at output**
1	1 V	0.5 V
5	5 V	2.5 V
10	10 V	5 V
20	20 V	10 V

The common-mode voltage increases linearly with the number of sensors. The voltages quickly exceed the limits of standard measurement systems:

Why is this a problem?

Most measurement systems (for example NI DAQ systems):

- Have a limited input range
- Cannot handle large common-mode voltages

Result:

- Measurement becomes inaccurate (the amplifier saturates)
- Or the signal may be completely lost

High-end multimeters (e.g. 6½ digit DMMs) can handle high common-mode voltages due to their true differential inputs. Even in multi-instrument systems (e.g. GPIB or USB setups), this approach remains valid.

Otherwise switching or multiplexing (with for example gold plated relays) is required.

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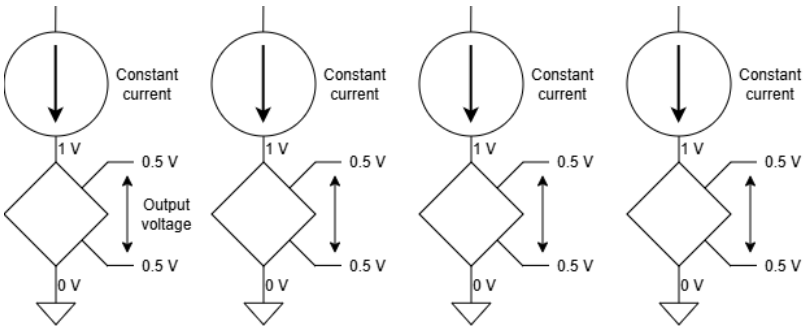
Additional drawbacks

- Long wiring loop on the input current side, can pick up more electromagnetic interference (EMC)
    - The Hall sensors themselves have no intrinsic EMC sensitivity at all. However, the wiring and the measurement system input can pick up interference, which can affect the measurement.
- If one sensor fails, the entire chain stops working

2. Individual Sensors (Separate Connections)

How it works

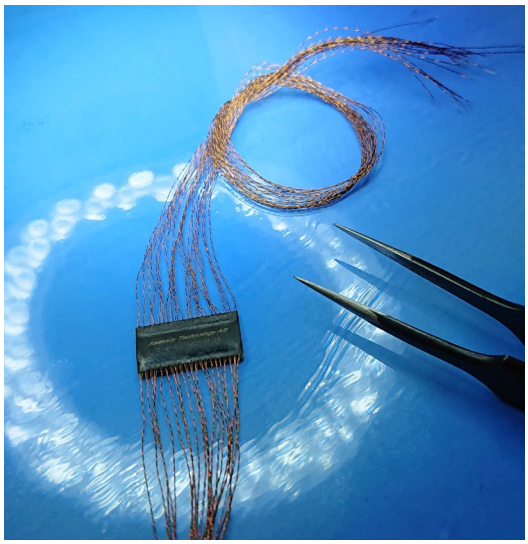


Each sensor is connected separately:

- It has its own current source
- It has its own measurement wires
- 4 wires per sensor
- In the picture on the right, you can see the setup and the common mode voltage at zero magnetic field.

Advantages

- No accumulation of common-mode voltage
- Works with all standard measurement equipment, compatible with ADC systems
- Better fault tolerance (one sensor failure does not affect others)
- Easier EMC and noise control (short local loops)



Disadvantages

- More wiring (significant for large arrays)
- Multiple current sources needed
- More complex system design

Practical Notes

- Hall sensors should be driven with a constant current for accurate measurements
- Twisted wires (as visible in the photos) help reduce noise pickup
- Good wiring and amplification are important

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Summary

Rule-of thumb for common mode voltage in series connection:

Each additional sensor increases the common-mode voltage.
In typical use, this is about 0.5 V per sensor

Aspect	Series Connection	Individual Sensors
Wiring	Minimal	Many wires
Current sources	One	Multiple
Common-mode voltage	Increases with sensors	Stable
Measurement compatibility	Limited	Good
Reliability	Lower	Higher

Choosing the wrong readout method can make the system unusable or require complex redesign. This is especially important for high-value sensor arrays. For most standard ADC-based systems, individual sensor readout is strongly recommended.

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