

Grounding Needs of Instrumentation

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Grounding Needs of Instrumentation

Overview



Instrumentation needs to be grounded:

- For safety reasons:
 - Exposed conductive controls cannot have hazardous voltages
 - In case of a failed connection, the case must still be safe
- To minimize noise introduced into the measurement
 - If shields are not at the same voltage as the sensitive measurement, noise is capacitively coupled into the experiment
 - Where to connect the shields and grounds?

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Grounding Needs of Instrumentation

Overview

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Where to connect shields and ground?

To answer this:

- Analyze the building
- Analyze the experiment
- Analyze the instrumentation
- Analyze the complete circuit

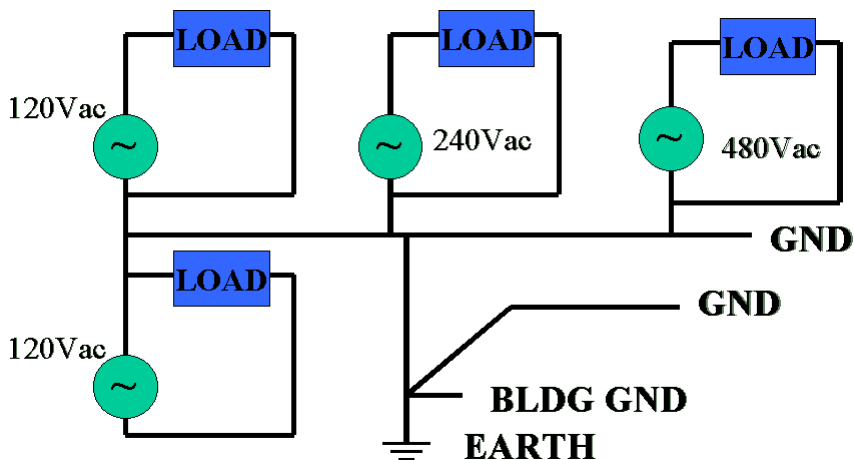
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The Building [typical]

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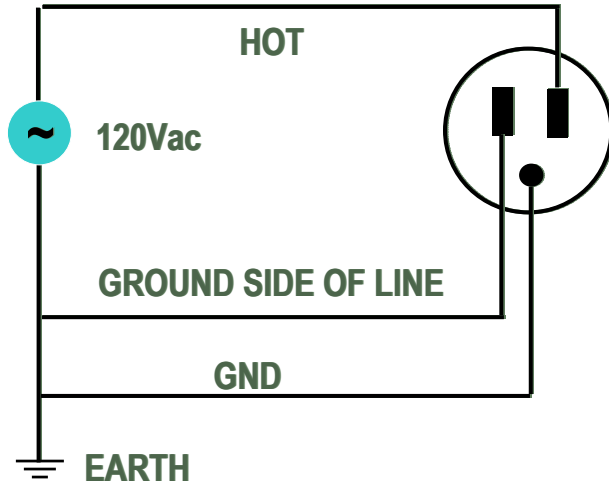


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User's View of the Building

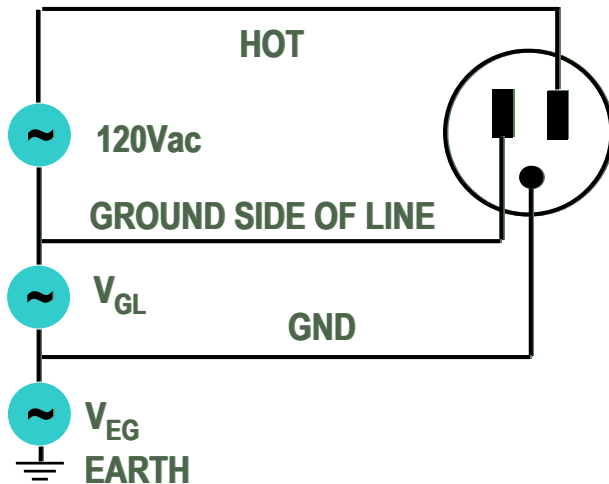


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Equivalent Building Circuit



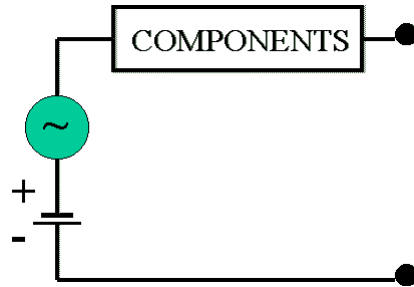
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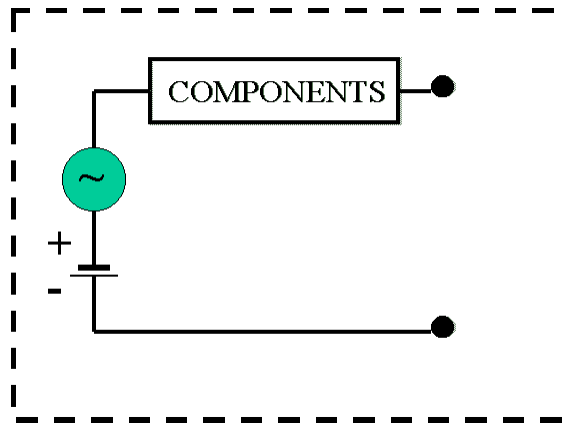
The Experiment



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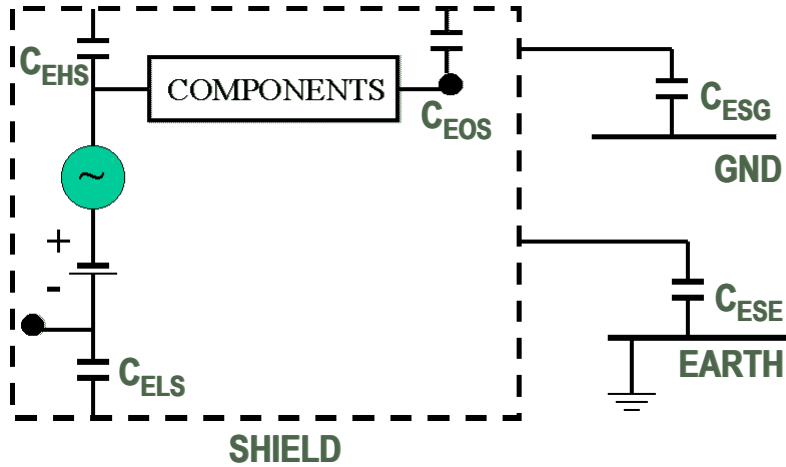


Experiment with Shield



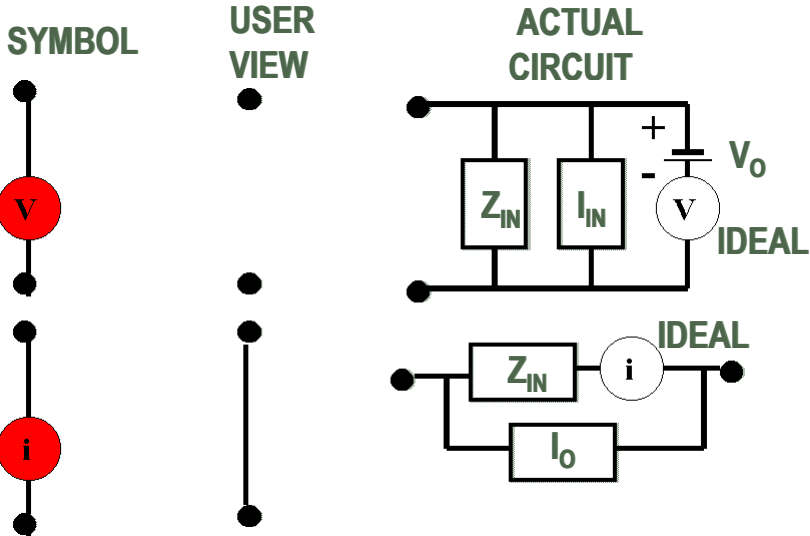
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Experiment & Shield in Building



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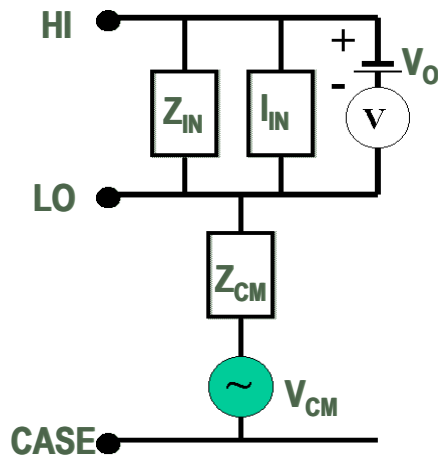
Meter Circuits



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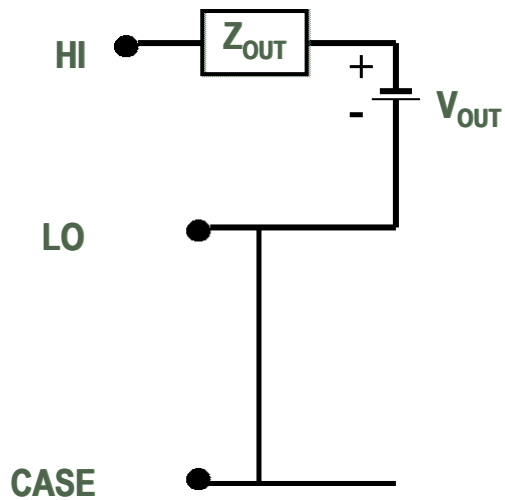
Floating Voltmeter Equivalent Circuit



Grounding Needs of Instrumentation

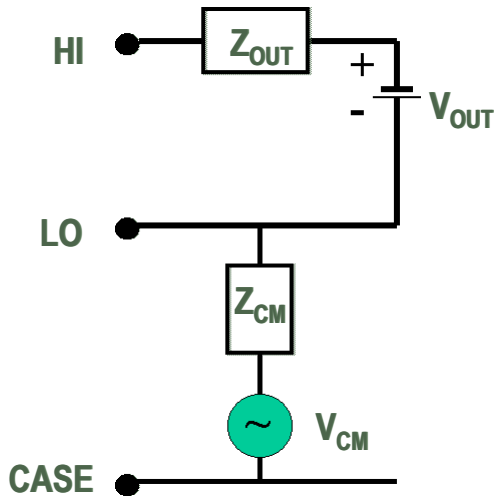


Grounded Source Equivalent Circuit



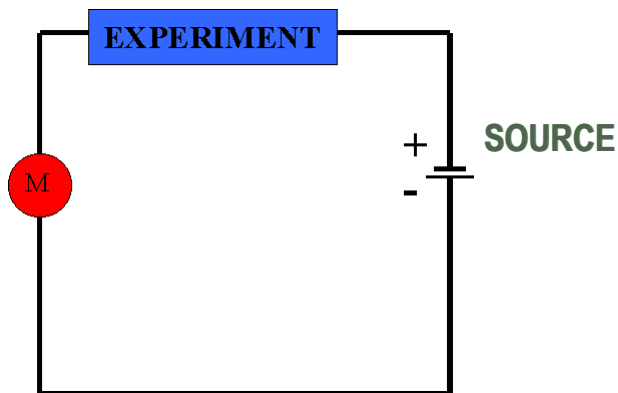
Grounding Needs of Instrumentation

Floating Source Equivalent Circuit



Grounding Needs of Instrumentation

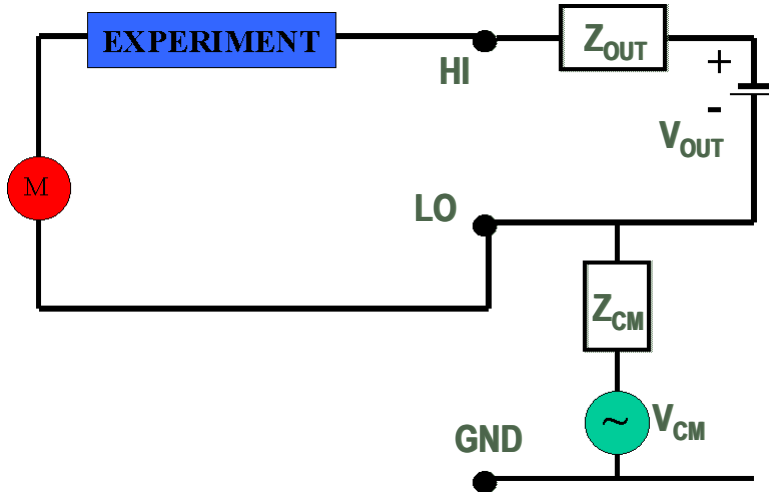
THE USER CIRCUIT



Now we substitute previously developed circuits for each element:

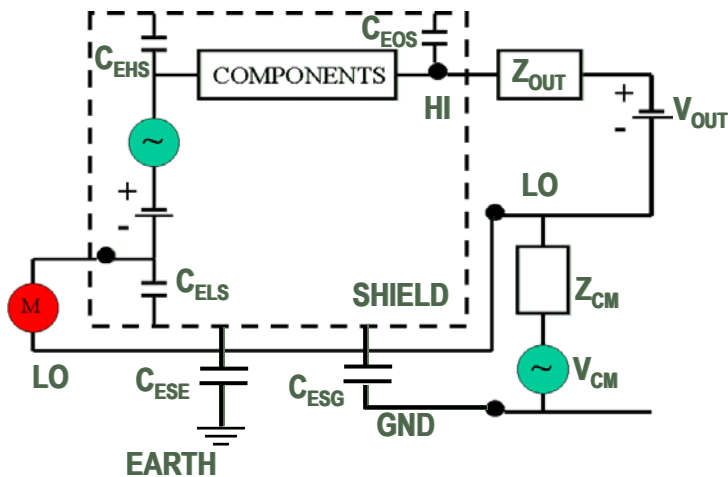
Grounding Needs of Instrumentation

Floating Source Circuit in USER CIRCUIT



Grounding Needs of Instrumentation

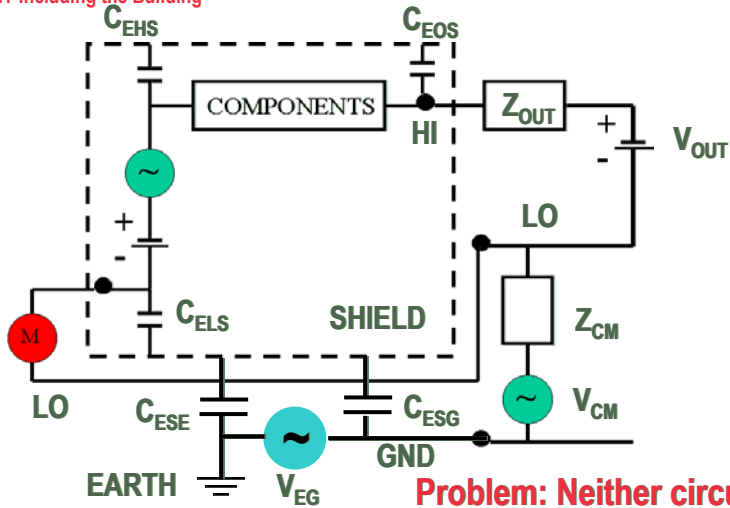
Floating Source, Floating Shield
USER CIRCUIT



Grounding Needs of Instrumentation

Floating Source, Floating Shield
USER CIRCUIT Including the Building

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Shield and Ground Connections

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Where to connect shields and ground?

- Analyze the building
- Analyze the experiment
- Analyze the instrumentation
- Analyze the complete circuit

As shown, both SHIELD and LO are floating

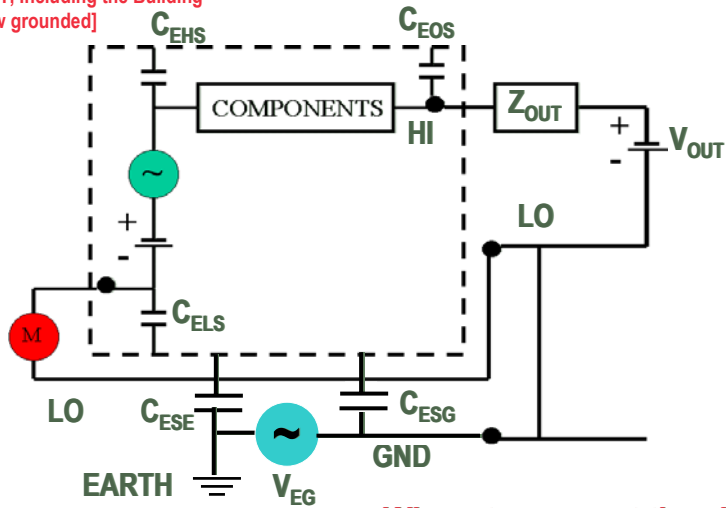
[Not tied to any low impedance with respect to GND]

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Grounding Needs of Instrumentation

Grounded Source, Floating Shield Circuit
USER CIRCUIT, Including the Building
[Circuit is now grounded]



Where to connect the shield?

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Shield and Ground Connections

Where to connect shields and ground?

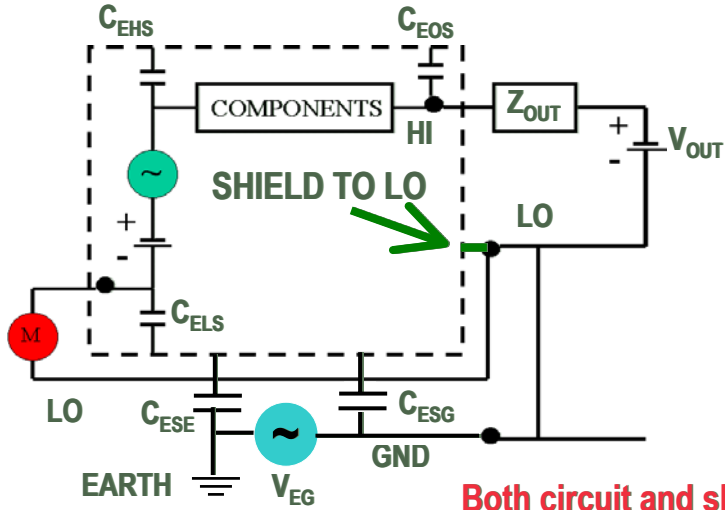
In grounded source case:

- Circuit LO is forced to GND by the source.
- Where to connect the shield?
If shields are not at the same voltage as the sensitive measurement, noise is capacitively coupled into the experiment.

IN THIS CASE, TIE SHIELD TO CIRCUIT LO = GND

Grounding Needs of Instrumentation

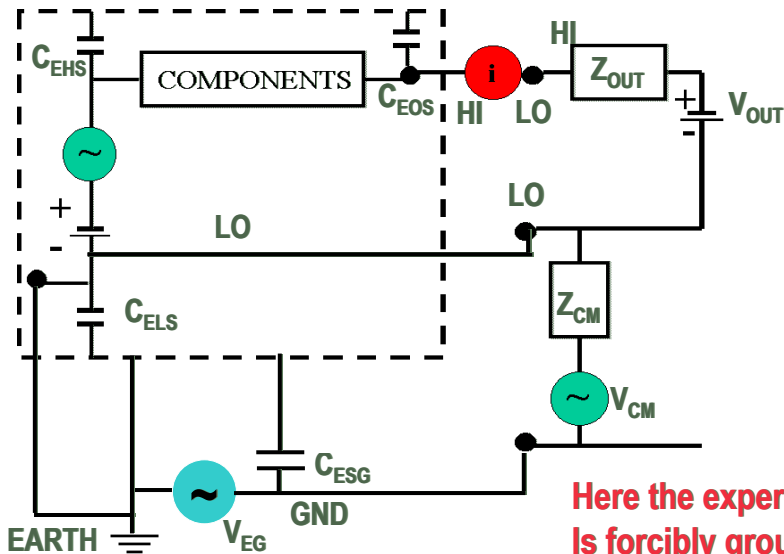
Shield and Ground Connections



Both circuit and shield are now committed

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Grounded Experiment Circuit



Here the experiment is forcibly grounded

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Shield and Ground Connections



When experiment is connected to earth [large apparatus connected to building or its own earth]:

- Connect LO to experiment near experiment source.

- Where to connect the shield?

If shields are not at the same voltage as the sensitive measurement, noise is capacitively coupled into the experiment.

IN THIS CASE, TIE SHIELD TO EARTH REFERENCE BUS

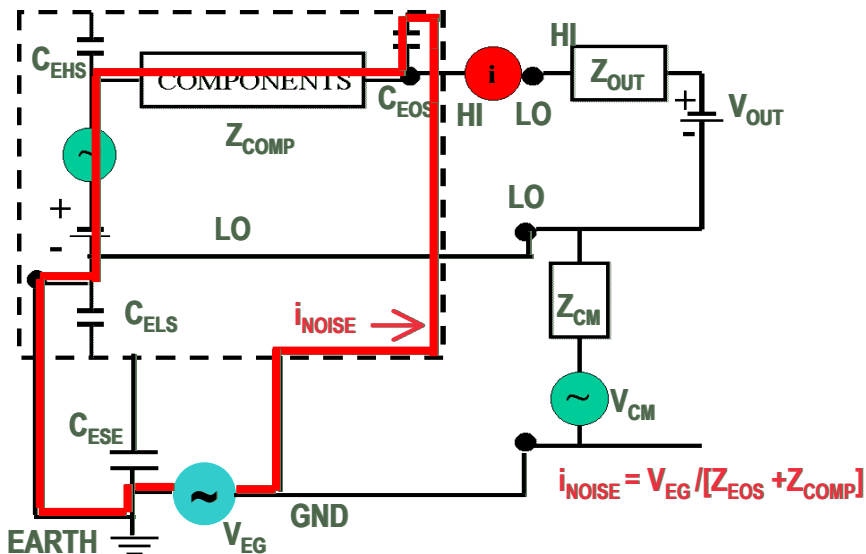
If it is connected to GND, V_{EG} will create noise in the experiment through capacitive coupling via C_{EOS} .

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Noise in Grounded Experiment Circuit



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Earth Reference Bus



THE EARTH REFERENCE BUS:

- Needed where sensitive experiments or apparatus is unavoidably are tied to earth
- ONLY used as a reference
- No current dumped into it
 - All source-load loops are completed external to the bus
- Use large flat busbar if a lot of sensitive high-frequency work is being done; large copper wire if this is too expensive
- Star configuration; large conductors where many join
 - NO LOOPS; LOOPS IS BAD
 - Encircle building to minimize outside fields
 - Overlap conductors in encircling, but do not connect in loops
- OK to connect to earth with grounding rods at multiple points
- Only one connection to building ground, at main ground point