Exploring current sense amplifiers

STMicroelectronics Tech Days

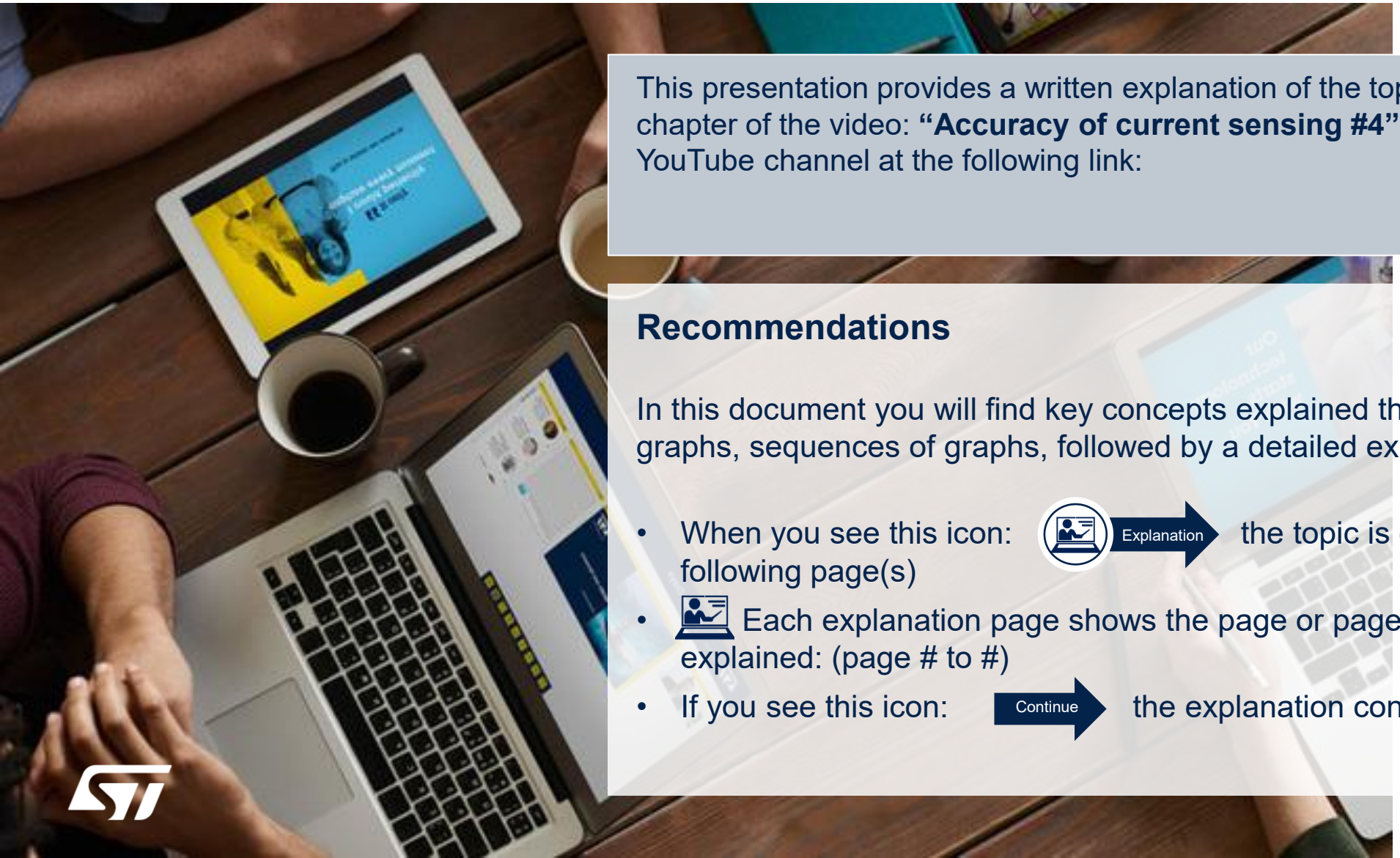
Accuracy of current sensing

Chapter 4

Parameter detailed

- Error source acting as an offset
- Error source acting as a ratio of current
- Error source application dependent

User guide



This presentation provides a written explanation of the topic covered in the second chapter of the video: **“Accuracy of current sensing #4”**, which is available on our YouTube channel at the following link:

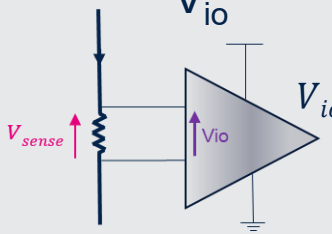
Video on YouTube

Recommendations

In this document you will find key concepts explained through informative tables, graphs, sequences of graphs, followed by a detailed explanation.

- When you see this icon: Explanation the topic is explained in detail on the following page(s)
- Each explanation page shows the page or page range where the topic is explained: (page # to #)
- If you see this icon: Continue the explanation continues on the next page(s)

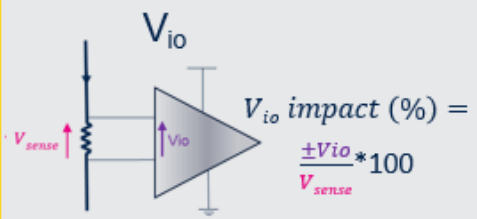
Three main error categories

	Error source acting as an offset	Error source acting as a ratio of current	Error source application dependent
Main parameter involved	• V_{io} • $\Delta V_{io}/\Delta_T$ • CMRR • SVR	• Gain • Linearity • Output common voltage	• Shunt • I_{IB}
First order approximation	V_{io}  $V_{io}\ impact\ (\%) = \frac{\pm Vio}{V_{sense}} * 100$	Gain Eg | Gain error | ΔV_{OUT} = 100 mV to (V_{CC} - 100 mV) Tmin < T < Tmax | 0.01 | 0.3 0.35 | %	Shunt STANDARD ELECTRICAL SPECIFICATIONS GLOBAL MODEL: WSBS5216 | SIZE: 5216 | POWER RATING $P_{70\,°C}$ W: 12 | TOLERANCE ± %: 5, 10 | RESISTANCE VALUE RANGE Ω: 50µ to 250µ | RESISTANCE VALUES CURRENTLY AVAILABLE (1) Ω: 100µ | WEIGHT (typical) g: 19.2
Main impact	Low current	High current	High current

Explanation

Three main error categories

Explanation of page 4

	Error source acting as an offset
Main parameter involved	• V_{io} • $\Delta V_{io}/\Delta_T$ • CMRR • SVR
First order approximation	
Main impact	Low current

Any electronic component, active or passive, introduces errors in the measurement chain where it is used. Current-sensing circuits are no exception: several parameters affect the accuracy of the measured current. These parameters can be grouped into three main categories.

1. **Error sources acting as an offset**
   The first category corresponds to errors that add an almost constant offset to the measurement. This offset has the largest impact at low current, where it can represent a significant portion of the measured value.

Key contributors are amplifier-related parameters such as:

- input offset voltage V_{IO},
- its drift versus temperature $\Delta V_{\mathrm{IO}}/\Delta T$,
- the common-mode rejection ratio (CMRR),
- and the supply-voltage rejection (often called SVR or PSRR).

Three main error categories

Explanation of page 4

	Error source acting as a ratio of current
Main parameter involved	• Gain • Linearity • Output common voltage
First order approximation	Gain Eg | Gain error | ΔV_{OUT} = 100 mV to (V_{CC} - 100 mV) Tmin < T < Tmax | 0.01 | 0.3 0.35 | %
Main impact	High current

2. **Error sources acting as a ratio of current**
   The second group contains errors that can be expressed as a percentage of the measured current, regardless of its absolute value. This includes:

   - gain error,
   - gain linearity over the full measurement range,
   - and, for bidirectional current sensing, errors on the output common-mode voltage.

These errors are relatively easy to express because they are independent of the application and the current to be measured. While offset-type errors dominate at low currents, these ratio-type errors become more significant from medium to high currents.

Three main error categories

Explanation of page 4

	Error source application dependent
Main parameter involved	• Shunt • I_{IB}
First order approximation	Shunt
Main impact	High current

STANDARD ELECTRICAL SPECIFICATIONS

GLOBAL MODEL	SIZE	POWER RATING $P_{70\,°C}$ W	TOLERANCE ± %	RESISTANCE VALUE RANGE Ω	RESISTANCE VALUES CURRENTLY AVAILABLE (1) Ω	WEIGHT (typical) g
WSBS5216	5216	12	5, 10	50µ to 250µ	100µ	19.2

3. Application-dependent error sources

The third category contains errors that depend on the application itself, in particular:

- the shunt resistor accuracy,
- and the input bias current I_B of the current-sense amplifier.

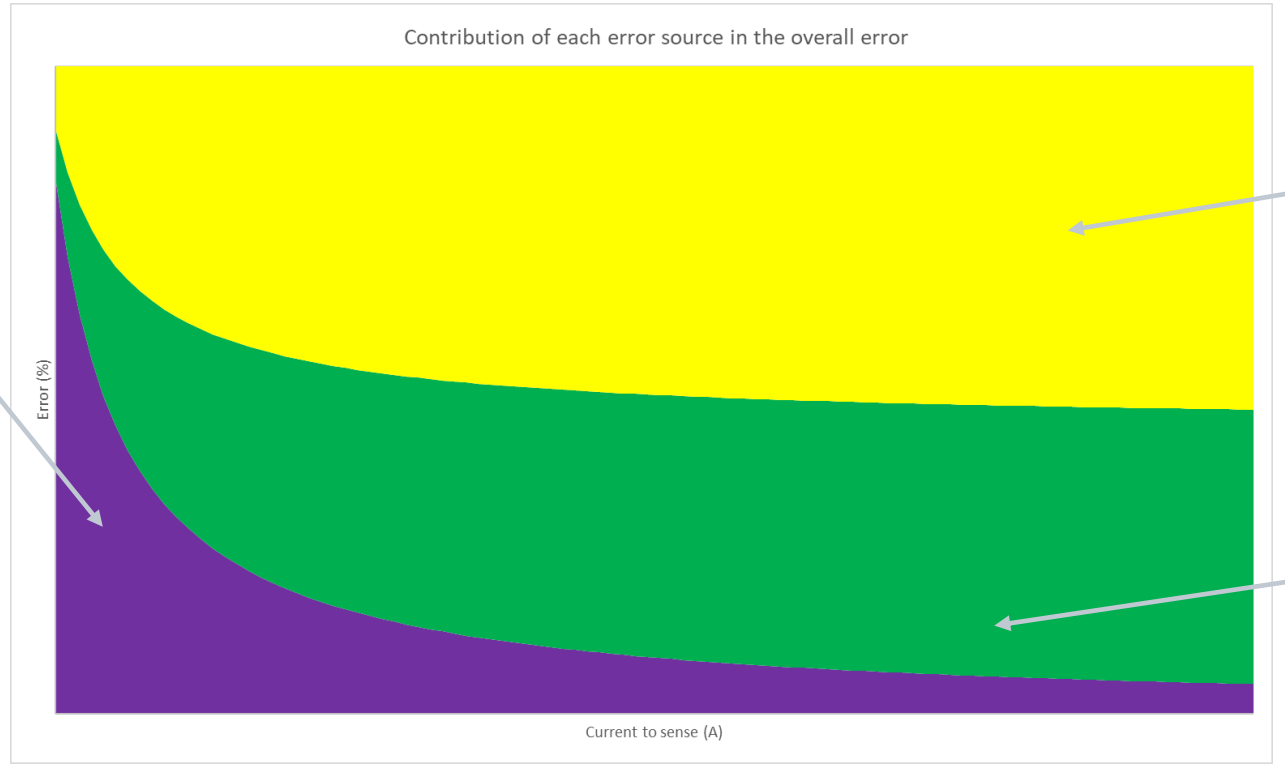
The shunt tolerance also behaves like a percentage error, so it could be grouped with the second category, but it is strongly linked to application conditions. The input bias current may either limit the measurable current range or introduce an additional offset, depending on the circuit configuration.

These three categories provide a practical framework for analyzing and budgeting current-measurement errors.

Error source impact on current sensing accuracy

With a two-decade current flowing into the shunt, different error sources do not have the same impact on output precision

Error source acting as an offset is the highest contributor to output error, when low current flows into the shunt (ex: V_{io})



Error source depending on the application is the highest contributor to output error, when high current flows into the shunt (ex: shunt)

Error source acting as a ratio of current is the highest contributor to output error, when high current flows into the shunt (ex: gain error)

Explanation

Error source impact on current sensing accuracy

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This chart summarizes how the three error categories affect accuracy as a function of the measured current amplitude.

The purple area represents offset-related errors. It shows that, at the lowest current levels, offset is the dominant contributor to the total error. As the measured current increases, the relative impact of this offset decreases.

At higher currents, the errors that act as a percentage of the measurement (such as gain error) and the application-dependent errors (such as shunt tolerance) become predominant in the overall error budget.

This short chapter is only an introduction to the main error sources to consider when selecting a current-sense solution. In the following videos, each parameter and its direct impact on the application will be analyzed in detail.

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