Current Sensing with INA226-Q1 in HEV/EV BMS

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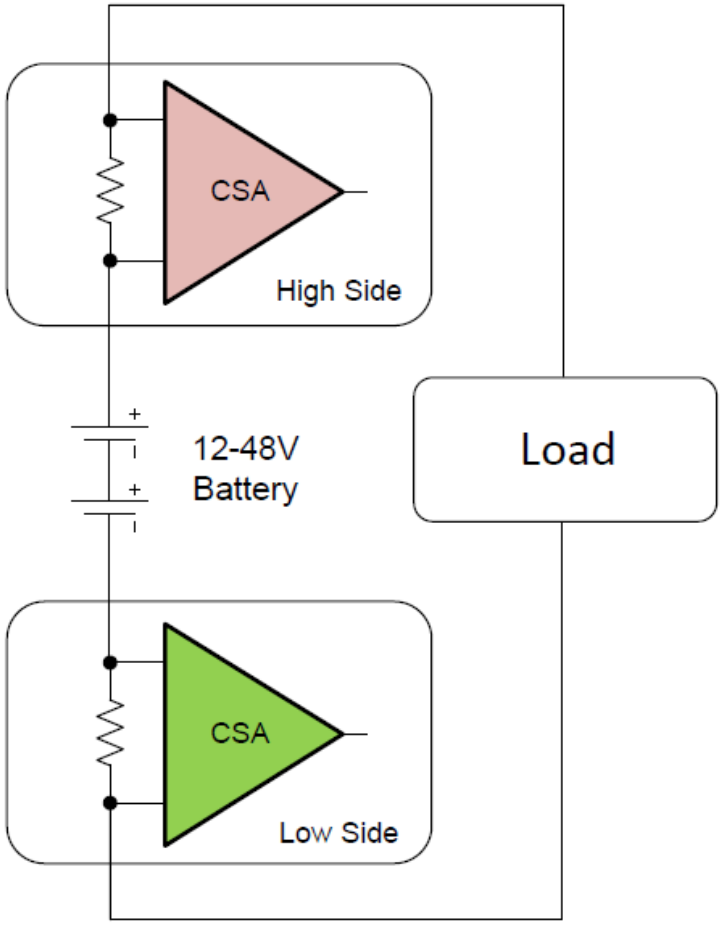
Current and Magnetic Sensing

Topics

- Shunt based current sensing in BMS
- INA226 features
- Optimize for Speed and Accuracy of INA226
- Comparative Study of Speed and Accuracy

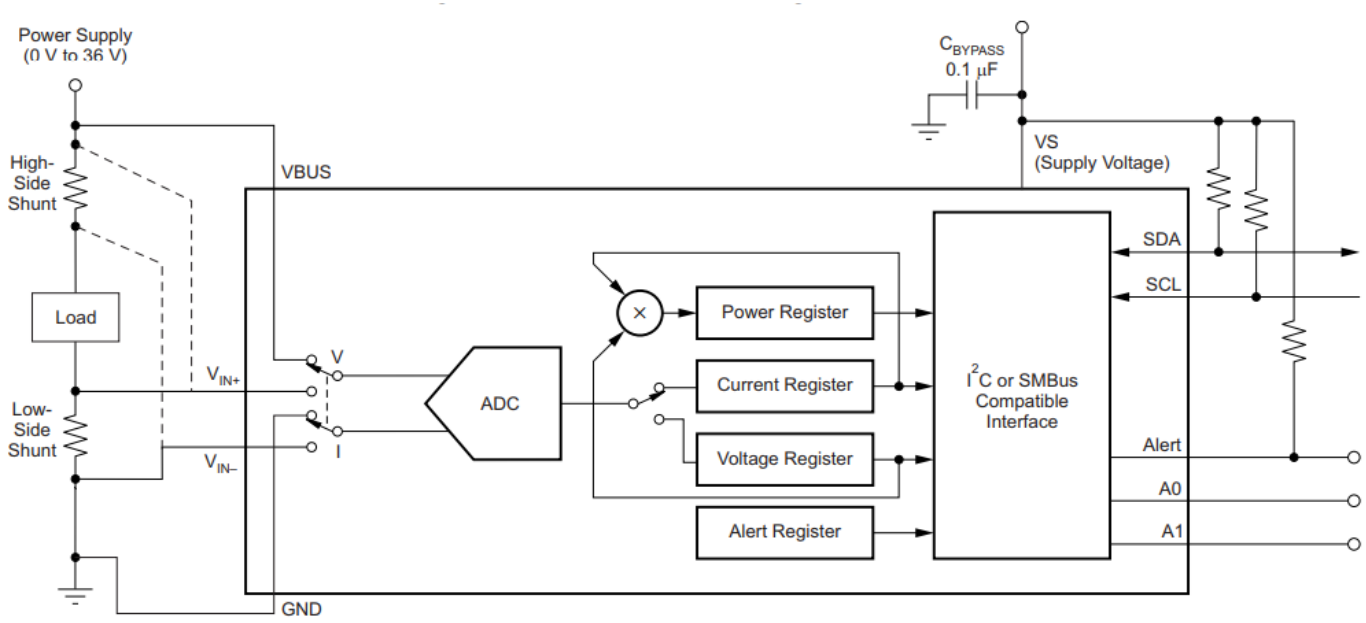
Current Sensing for Low Voltage BMS

- Configurations
  - Top of stack
  - Bottom of stack
- Current sensing challenges
  - Wide current range
  - Error at low current
  - Temperature drift



INA226 Features

- **INA226 features**
  - Senses Bus Voltages From 0 V to 36 V
  - High or Low side
  - Reports Current, Voltage, and Power
  - High Accuracy:
    - 0.1% Gain Error (Max)
    - 10 µV Offset (Max)
    - 0.1uV/ºC Offset Drift (Max)
    - 50ppm/ºC Gain Error Drift(Max)
  - Configurable Averaging Options
  - 16 Programmable Addresses
  - Operates from 2.7-V to 5.5-V Power Supply



• Optimize for Speed and Accuracy of INA226-Q1

Step 1

MODE3 D2	MODE2 D1	MODE1 D0	MODE[1]
0	0	0	Power-Down (or Shutdown)
0	0	1	Shunt Voltage, Triggered
0	1	0	Bus Voltage, Triggered
0	1	1	Shunt and Bus, Triggered
1	0	0	Power-Down (or Shutdown)
1	0	1	Shunt Voltage, Continuous
1	1	0	Bus Voltage, Continuous
1	1	1	Shunt and Bus, Continuous

Step 2

AVG2 D11	AVG1 D10	AVG0 D9	NUMBER OF AVERAGES[1]
0	0	0	1
0	0	1	4
0	1	0	16
0	1	1	64
1	0	0	128
1	0	1	256
1	1	0	512
1	1	1	1024

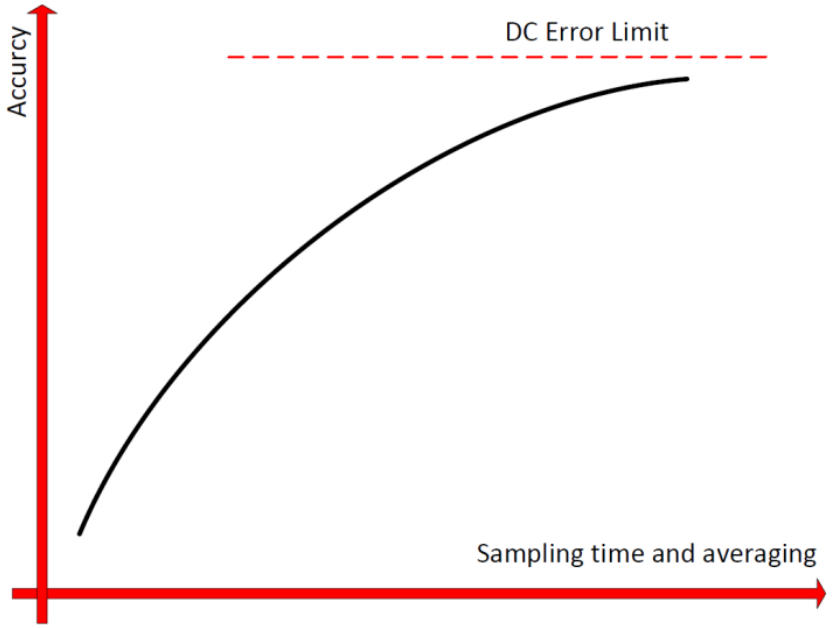
VBUSCT2 D8	VBUSCT1 D7	VBUSCT0 D6	CONVERSION TIME[1]
0	0	0	140 µs
0	0	1	204 µs
0	1	0	332 µs
0	1	1	588 µs
1	0	0	1.1 ms
1	0	1	2.116 ms
1	1	0	4.156 ms
1	1	1	8.244 ms

VSHCT2 D8	VSHCT1 D7	VSHCT0 D6	CONVERSION TIME[1]
0	0	0	140 µs
0	0	1	204 µs
0	1	0	332 µs
0	1	1	588 µs
1	0	0	1.1 ms
1	0	1	2.116 ms
1	1	0	4.156 ms
1	1	1	8.244 ms

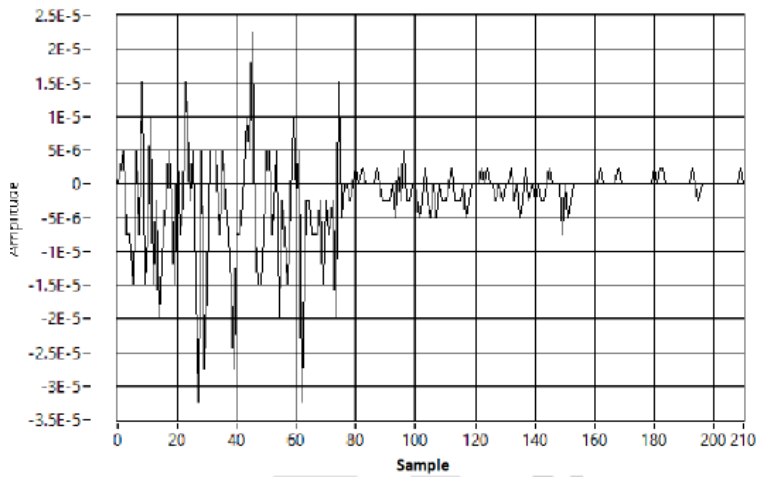
- Only VBUS and Vshunt measurement takes conversion time
- Current and power calculations happen in the background and do not contribute to conversion time.
- Two step optimization for a given data rate (total conversion time)
- Step 1 Decide what parameters to measure – VBUS, Vshunt or both
- Step 2 Allocate conversion time and averaging to VBUS and Vshunt measurement, with the goal of achieving required accuracy within the maximum allowed conversion time.

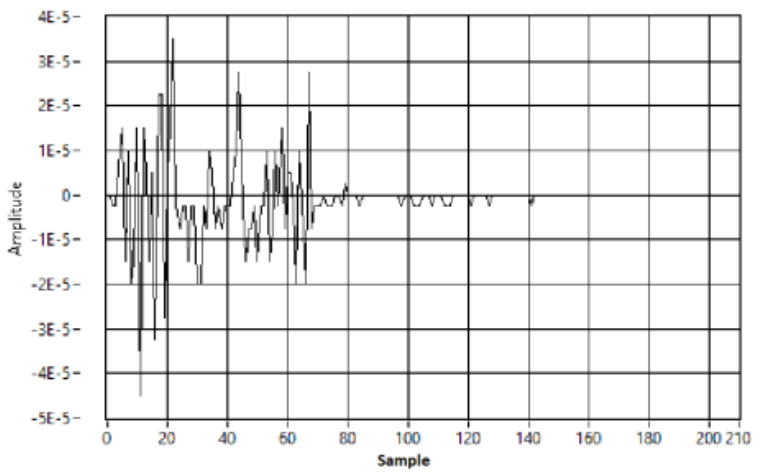
An Example of Accuracy vs Speed Optimization

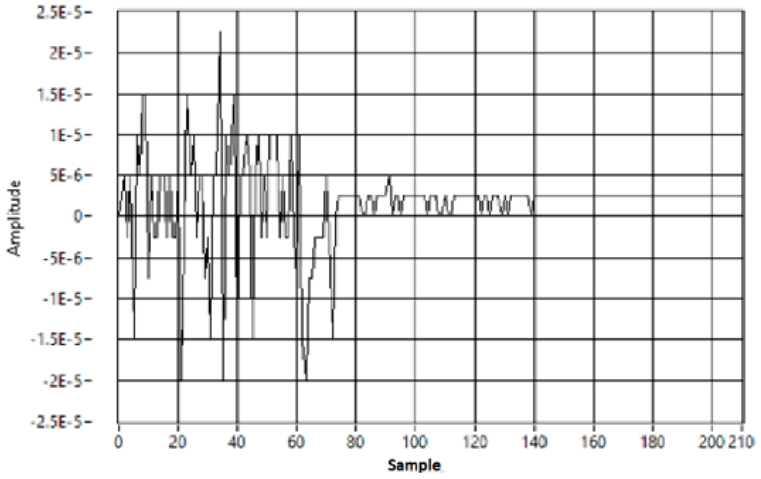
- **Want**: Voltage, Current, and Power every 5mS (data rate=200 SPS)
- **Approach #1**:
  - Conversion time = 588µs for both Vshunt and Vbus;
  - Averaging = 4 for both.
  - Data updating approximately every 4.7ms
- **Approach #2**:
  - Vshunt conversion time =4.156 ms; averaging = 1.
  - Vbus conversion time = 588 µs; averaging = 1.
  - Data updating approximately every 4.7ms
  - More time allocated to Vshunt
  - Vshunt is usually the more challenging measurement



INA226 Comparative Study of Speed and Accuracy







- Compare the effect of conversion time and averaging on noise.
- Longer conversion time improves accuracy.
- Averaging improves accuracy.
- Use a combination of the longest allowable conversion times and highest number of averages

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