Isolated Voltage and Current Monitoring in Automotive Applications Using the VOA300

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Automotive applications such as battery charge monitoring, leakage detection, onboard chargers, DC/DC converter stages, and motor drives require galvanically isolated current and voltage measurements to protect low voltage circuitry from the high voltage (HV) side. These applications also require the measurement data to be transferred to the control system at a fast rate to allow the safety mechanisms to perform their functions in case of high surge currents or voltage spikes. The VOA300 is a fast response analog linear optocoupler that allows high side voltage and current measurements using a shunt resistor. The VOA300's wide bandwidth of 1.4 MHz allows for high speed measurements and fast data transmissions. Furthermore, its high stability and excellent linearity over temperature make it a suitable candidate for harsh automotive applications. It can also be used to transfer high voltage side battery cell temperatures measured using a thermistor or an RTD.

State of the art current and voltage measurement techniques involve the use of digital isolators, which need an A/D converter on the input side and an additional D/A converter on the output side. Also, these digital isolators suffer from EMC-related issues, which is quite well-known. With the common trend of moving to high voltage batteries comes a great responsibility for designers: limiting the electromagnetic interferences by using optical coupling technologies. Being an analog device, the VOA300 has a clear advantage here over digital isolators, which use RF frequencies.

Another popular solution is voltage and current measurements using isolation amplifiers. Such parts use inductive or capacitive isolation techniques, which results in costly solutions. These isolation amplifiers are also limited by the bandwidth up to a maximum of 200 kHz. The VOA300 eliminates all such disadvantages, providing designers with the flexibility to decide the accuracy of the solution with the individual choice of op-amps, resistors, and other external components.

This application note describes the typical voltage and current measurement circuits for automotive applications.

1. Battery Current Monitoring

   The schematic below shows a circuit designed for galvanically isolated transmission of battery current from the HV side to the low voltage (LV) side over the optical isolation barrier. The current is measured as a voltage drop over a low resistance shunt, connected in series to the battery and the load. The input stage consists of a servo amplifier, which controls the LED forward current. The servo photodiode is operated with zero bias voltage. The servo photocurrent is linearly proportional to the input voltage, which is defined by the load current flowing through the shunt resistor R_{SHUNT}, $I_{P1} = (V_{RSHUNT} \times I_{LOAD}) / R_1$. A buffer amplifier (OPA2) is needed on the output to convert the current to voltage further to ADC.

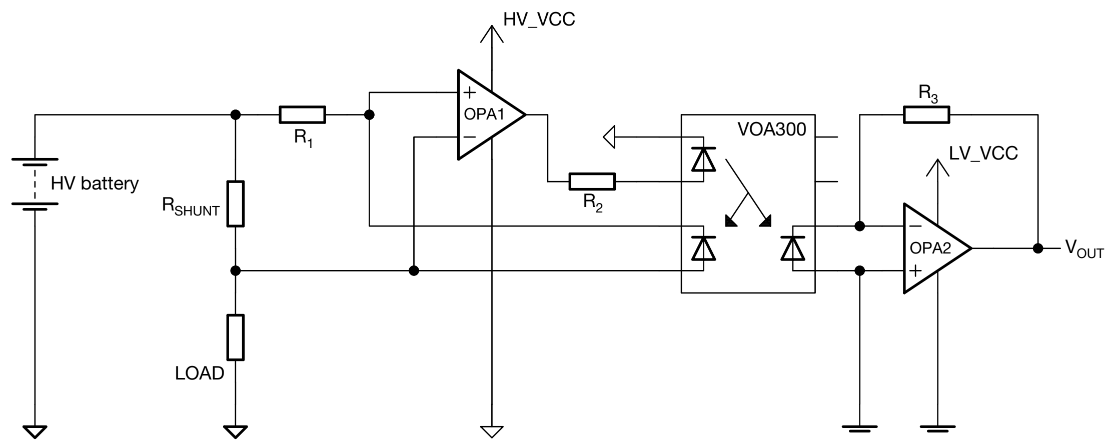

Fig. 1 - Current Sensing

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2. Battery Cell Voltage Monitoring

   The circuit for the battery voltage is similar to the circuit for the measurement of the current. Here, an additional amplifier stage ($OPA1_2$) is needed on the input side to minimize the influence of the high impedance resistors RA and RB.

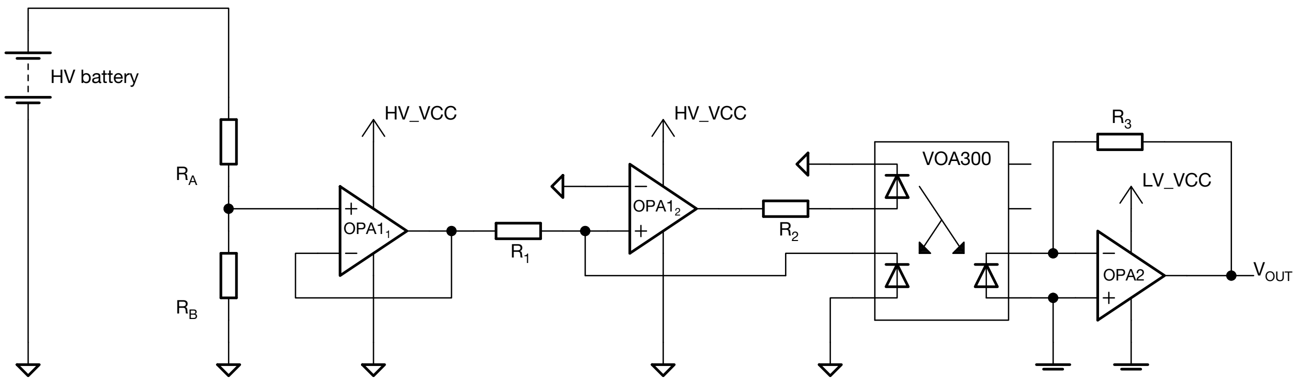

Fig. 2 - High Voltage Monitoring

   In both circuits described above, the designer has the choice of resistors and amplifiers to fit their accuracy and precision requirements.

3. Isolated Temperature Sensing

   Along with battery charge monitoring, temperature monitoring also plays a vital role in evaluating battery safety while charging and discharging, as well as optimizing the battery health. Temperature measurement is generally performed using resistive elements such as thermistors and RTDs due to their high accuracy and low cost. Applying them into a resistive voltage divider, these elements generate a voltage that is proportional to the temperature. There is need for the galvanic isolation between the resistive element and the system side when the element is on the HV side, or in an electrically noisy environment.

For further isolated amplifier designs, please refer to this application note. Another innovative state the art trend is replacing the mechanical fuses with a resettable fuse called an eFuse. The eFuse's principle function is to protect the user and hardware in electric vehicles (EV) by shutting off the battery voltage to the load circuit after a hazardous overcurrent event. Such an eFuse is realized with SiC MOSFETS and a VOA300 at Vishay in the form of a reference design [2][3]. Ask for more info at optocouplers.answers@vishay.com.

REFERENCE

[1] Optical Isolation Amplifiers Support Inverter Voltage, Current and Temperature Sensing | Electronic Design

[2] 800 V_{DC}, 50 A Bidirectional eFuse Reference Design (www.vishay.com)

[3] 400 V_{DC}, 100 A Bidirectional eFuse Reference Design (www.vishay.com)