Measurement of Automotive Module Sleep Current During Product Development

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# Introduction / Overview

Many modern automotive modules are constantly powered, and enter a low-power mode (often called “sleep”) to minimize battery drain when the vehicle is not being used. During normal operation, current draw might be measured in amperes; whereas in sleep, current might be measured in microamperes (a current range of about a million to one). Supplying normal operational current while preserving the ability to measure the very small sleep current is a technical challenge. This document describes an approach that will work for most modules.

# Design Requirements

In order for the described approach to work, it is required that the module whose sleep current is being measured has the following characteristics:

* (Requirement 1) It is possible to control when the module enters and exits sleep mode. (This is typically done using network traffic and directly-connected inputs.)
* (Requirement 2) The module does not have an overly sensitive LVI circuit that will cause a reset or wakeup when S1 is opened to measure current.

In general, any measurement approach must meet these requirements:

* (Requirement 3) The approach must be able to measure low current with ±5% accuracy, but hopefully with ±1%.
* (Requirement 4) The current measurement must not create excessive voltage drop across the measurement device.
* (Requirement 5) Testing mistakes or a module exiting sleep mode unexpectedly must not cause hardware damage.

A typical mechanical microammeter (low-current galvanometer), such as that shown in Figure 1, does not meet (Requirement 5) because an unexpected current increase (a testing mistake or the module unexpectedly exiting sleep) will destroy the meter.



Figure 1: Typical Low-Current Galvanometer

# The Proposed Approach

## Schematic Diagram

Figure 2 provides a schematic diagram of the proposed solution.



Figure 2: Schematic Diagram of Proposed Solution

The components and variables shown are:

* S1, an SPST switch. S1 is kept closed to operate the module under test normally and to place it into sleep mode. Once in sleep mode, S1 is opened to measure sleep current.
* RS, the shunt resistor used to measure current (and the value of the shunt resistor, in ohms).
* IS, the current flowing through RS.
* RM, the modeled resistance of the voltmeter used to measure the voltage across RS.
* IM, the current flowing through RM.
* VM, the voltage across RM.
* IT, the total current flowing through the module under test.
* For analysis, ISLEEP is used to denote the approximate typical current flowing through the module under test while it is in sleep mode.
* For analysis (see TBD), the variable α is used to represent permissible measurement error. α is dimensionless and represents ΔV/V or ΔI/I. For example, α = 0.01 would represent a permissible error of 1%.

## Physical Packaging

Need to include a proposed physical packaging.



Figure 3: Recommended Physical Packaging of Proposed Solution

## Operation

To use the proposed device, the following steps apply:

* S1 should be closed. (With S1 closed, the module under test can draw normal operational current.)
* The module under test should be placed into sleep mode.
* S1 should be opened. (This will introduce a small voltage drop to the module under test, and allow the measurement of ISLEEP by measuring VM, the voltage across shunt resistor RS.)
* VM should be measured.
* ISLEEP should be calculated.

## Analysis of (Requirement 3): Accuracy

Measuring the voltage across the current shunt RS using a voltmeter affects the voltage, because some current flows through the voltmeter. Although a typical digital voltmeter has a high input impedance (10MΩ is typical), the error should be analyzed.

RS would ideally be chosen to give an easy-to-calculate relationship between ISLEEP and VM. For example, for a module where ISLEEP is expected to always be less than 1mA (1000µA), it would be ideal to choose RS so that 1mV of VM represents 1µA of ISLEEP.

There are three obvious approaches to selecting RS:

1. Select RS for an easily-calculated relationship between ISLEEP and VM, make an assumption about minimum RM, and ensure that RS and RM are compatible in that the desired measurement error α is not exceeded.
2. Assume a specific RM and choose RS so as to preserve the easily-calculated relationship between ISLEEP and VM.
3. Use a less-than-easy method to calculate ISLEEP from VM.

Method (1) is the laziest method, and this is the only one explored. We need to determine the necessary relationship between RS and RM to have the desired accuracy of α = 0.01 = 1%.

The accuracy requirement directly implies that:

 (1)

 (2)

 (3)

 (4)

 (5)

 (6)

For example, if RS = 1KΩ is chosen and an accuracy of α = 0.01 = 1%, (6) implies that RM ≥ 99 RS = 99KΩ; and just about any modern digital voltmeter has RM >> 99KΩ.