

Measuring Current To Detect Out-of-Range Conditions

Scott Hill, Current Sensing Products



The amount of current flowing throughout a system provides insight in determining how effectively the system is operating. A basic insight into the system's operation is a comparison between the current being pulled from a power supply and a pre-defined target range for that particular operating condition. Current levels exceeding the expected current level indicate that an element in the system is consuming more power than expected. Likewise, if the current is lower than expected it may indicate some part of the system is not powered correctly or possibly disconnected.

There are multiple methods available to diagnose fault conditions in a system depending on how the out-of-range indication is intended to be used. One method is to monitor an entire system's current consumption to identify potentially damaging excursions for the power supply. In this case, measurement accuracy is typically not critical and requires a simple alert to indicate an out-of-range condition.

Fuses are commonly used for short-circuit protection preventing damaging levels of current from flowing in the system. In an out-of-range event the fuse will blow and break the circuit path. The fuse must be replaced for the system to operate correctly again. In worst case situations the system requires delivery to a repair facility if the fuse is not easily accessible.

There is a time-current dependency that limits the effectiveness of a fuse in responding to a specific current threshold. An example time-current response of a fuse is shown in Figure 1.

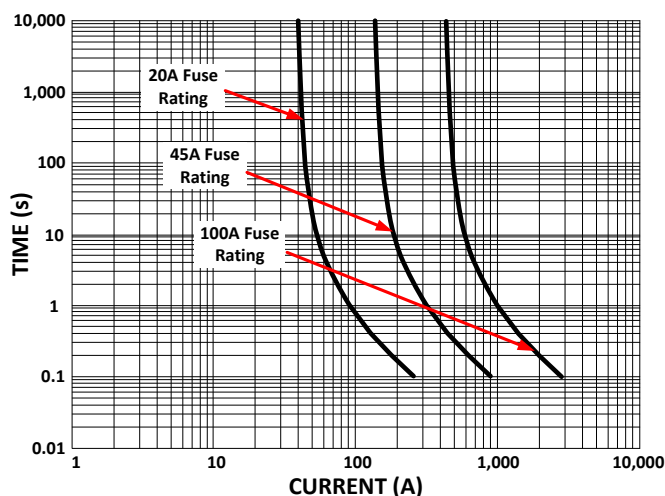


Figure 1. Typical Time-Current Fuse Curve

Another overcurrent protection scheme becoming more common is to allow the system to protect itself when an excursion is detected but then enable the system to return to normal operation once the fault condition has been cleared. This protection method uses a comparator comparing the monitored operating current levels to defined thresholds, looking for out-of-range conditions. Creating the necessary level of detection for a particular application relies on system specific variables such as the adjustability of the desired over-range threshold, the amount of margin acceptable in the threshold level and how quickly the excursion must be detected.

The INA300 is a specialized current sensing comparator with the ability to perform the basic comparison to expected operating thresholds required for out-of-range detection.

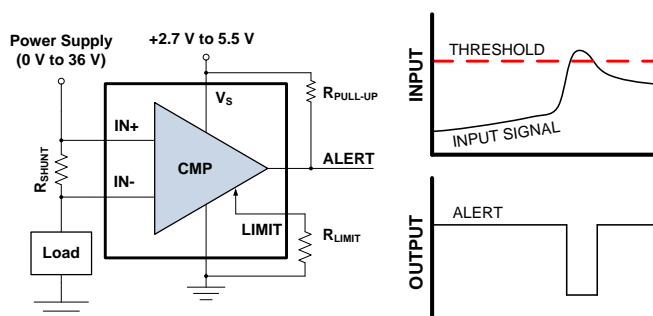


Figure 2. INA300 Over-Current Comparator

Figure 2 shows the INA300 measuring the differential voltage developed across a current sensing resistor and the comparison to a user-adjustable threshold level. The alert output is pulled low when the threshold level is exceeded. The INA300's alert response is issued following a current excursion in as short as 10μs.

There may also be a need to provide information on how much current is actually being pulled by the supply or a particular load in addition to the fault indication. For these requirements a typical approach is to utilize a combination of a current sense amplifier and a stand-alone comparator as shown in Figure 3.

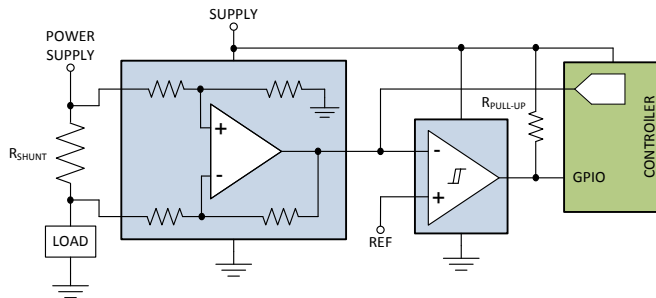


Figure 3. Discrete Over-Current Detection

The current sense amplifier measures the differential voltage developed across the sense resistor and sends the output to both the comparator input and analog to digital converter (ADC).

The **INA301** is a device that combines both the current sense amplifier (providing a voltage output signal proportional to the measured input current) and an on-board comparator (for over-current detection) into one device as shown in **Figure 4**.

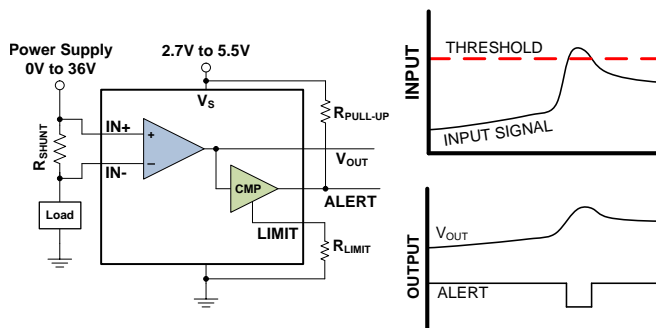


Figure 4. INA301 Integrated Over-Current Detection

With both the current information and an out-of-range indicator the system may utilize multiple monitoring and protection schemes based on the operating conditions. One scheme used with this device is to initially monitor only the alert indicator as a fault indicator. Once an out-of-range condition is detected and the alert pin is asserted, the system then begins actively monitoring the analog output voltage signal allowing the system to respond accordingly. The system response typically will be to reduce system performance level, shut down entirely or to continue monitoring to determine if the excursion continues to become a more significant system concern. Having both the proportional output voltage as well as the on-board over-current detection function allows the system to only actively monitor the current information when necessary optimizing system resources.

The **INA301** provides a combination of performance capability in addition to the integration of both the current sensing amplifier as well as on-board comparator. The **INA301** amplifier's has a small signal bandwidth of 450kHz at a fixed gain of 100 (gains of 20 and 50 are also available) and a maximum input offset voltage of 35μV. In addition to the maximum gain error specification of 0.2%, the amplifier's ability to detect the out-of-range condition is fast. The **INA301** is able to achieve accurate input measurements and quickly respond to over-current events with a response time including the input signal measurement, comparison to the user-selected alert threshold, and assertion of the comparator's output in less than 1μs.

Alternate Device Recommendations

For applications needing to monitor current on voltage rails that are higher than the **INA301**'s range of 36V with the on-board over-current detection, use the **INA200**. The **INA180** is a current sense amplifier that is commonly used in the discrete over-current detection circuit using an external comparator. For applications requiring monitoring of a second fault threshold level, the **INA302** features an additional out-of-range comparator with dedicated adjustable threshold level.

Table 1. Alternate Device Recommendations

Device	Optimized Parameter	Performance Trade-off
INA180	Package: SC70-5, SOT23-5	Reduced bandwidth, analog output only
INA200	Common-mode Voltage Range: -16V to +80V	Reduced accuracy
INA302	Two Independent Alert Comparators	Larger Package: TSSOP-14

Table 2. Related TI TechNotes

SBOA161	Low-Drift, Low-Side Current Measurements for Three Phase Systems
SBOA163	High-Side Motor Current Monitoring for Over-Current Protection
SBOA167	Integrating The Current Sensing Signal Path
SBOA168	Monitoring Current for Multiple Out-of-Range Conditions
SBOA193	Safety and Protection for Discrete Digital Outputs in a PLC System Using Current Sense Amplifiers

IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2017, Texas Instruments Incorporated