Introduction

Insulated-gate bipolar transistors (IGBTs) can fail when subjected to overloads and overvoltages. Isolation amplfiers (iso-amps) can respond quickly to over-current and overload conditions when used on the output phases and the DC bus.

A typical block diagram of a power converter in an AC motor drivet consists of an inverter that converts the DC bus voltage to AC power at a variable frequency to drive the motor. IGBTs are expensive power switches that form the heart of the inverter. These power devices must operate at a high frequency and must be able to withstand high voltages.

Iso-amps such as the ACPL-C79A work with shunt resistors to accurately measure power converter current even in the presence of high switching noise. When used with a resistive divider, iso-amps work as precision voltage sensors to monitor the DC bus voltage. The microcontroller monitors the current and voltage information from the iso-amps and uses the data to calculate the feedback values and output signals needed to for fault management in the IGBTs and power converters.

Fault Protection

However, the IGBT protection must be such that its cost doesn't affect that of the motor drive system. IGBT gate drivers such as the ACPL-332J and current sensors with protection features can detect faults economically in this regard. They eliminate the need for separate detection and feedback components. Over-current conditions in an IGBT can arise from a phase-to-phase short, a ground short or a shoot through. The shunt + iso-amp devices on the output phases and DC bus can, besides measuring current, detect such faults.

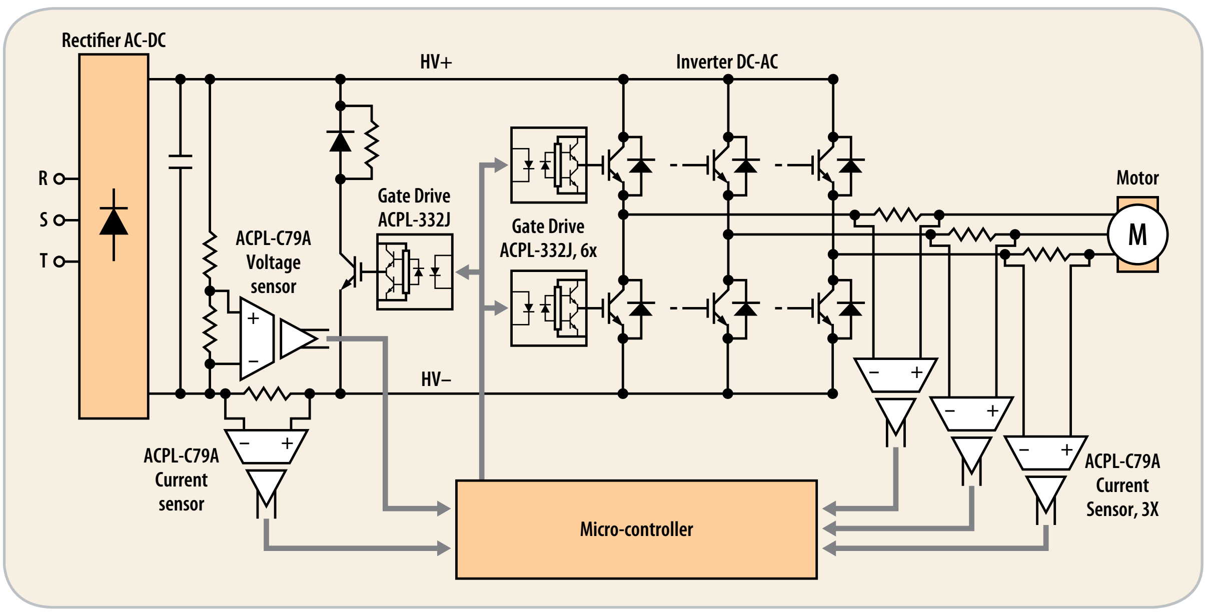
Typical IGBT short-circuit survival times are rated up to 10 µsec. So any protection must prevent this limit from being exceeded. Within 10 µsec, the circuit must detect the fault, notify the controller and complete the shutdown. Iso-amps use various methods to get these results.

For instance, the ACPL-C79A has a fast, 1.6 µsec response for a step input. That lets the iso-amp capture transients during short-circuits and overloads. The signal propagation delay from input to output at mid point is only 2 µsec, while it takes just 2.6 µsec for the output signal to catch up with input, reaching 90% of the final levels.

Another example is the HCPL-788J, which responds quickly to over-currents using a different approach. In addition to the signal output pin, it has a Fault pin that toggles quickly from High to Low level when over-current occurs. This iso-amp provides ±3% measurement accuracy.

In the fault feedback design, nuisance tripping can be an issue. This is a triggering of fault detection in the absence of any damaging fault condition. To avoid false triggering, the HCPL-788J employs a pulse discriminator that blanks out di/dt and dv/dt glitches. The advantage of this method is that

Figure 1: Block diagram of power converter in a motor drive



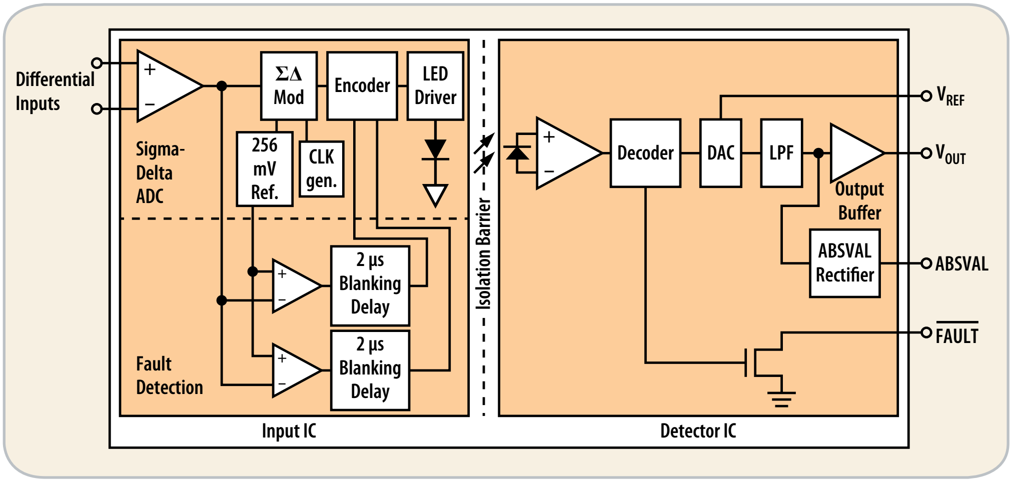


Figure 2: In the HCPL-788J iso-amp, the differential input voltage is digitally encoded by a sigma-delta A/D converter and then fed to the LED driver, which sends the data across the isolation barrier to a detector and D/A.

rejection is independent of amplitude, so the fault threshold can be set to low level without risking nuisance tripping.

The circuit that detects faults quickly contains two comparators in the Fault Detection block to detect the negative and positive fault thresholds. The switching threshold is equal to the sigma-delta modulator reference of 256 mV. The outputs of these comparators connect to blanking filters with a blanking period of 2 µsec and then go to the Encoder block.

To ensure speedy transmission of the fault status across the isolation boundary, two unique digital coding sequences represent the fault condition, one code for negative, the other for affirmative. Detection of a fault interrupts the normal data transfer through the optical channel and replaces the bit stream with the fault code. These two fault codes deviate significantly from the normal coding scheme, so the decoder on the detector side immediately recognizes the codes as a fault conditions.

The decoder needs about 1 µsec to detect and communicate the fault condition across the isolation boundary. The anti-aliasing filter adds a 400 nsec delay to give a propagation delay of 1.4 µsec. The delay between the fault event and the output fault signal is the sum of the propagation delay and the blanking period (2 µsec) for an overall 3.4 µsec fault detection time.

The Fault output pin allows fault signals from several devices to be wire-ORed together forming a single fault signal. This signal may then be used to directly disable the PWM inputs through the controller.

Overload Detection

An overload condition refers to a situation where the motor current exceeds the rated drive current, but without imminent danger of failure, as when the motor is mechanically overloaded or is stalling because of a bearing failure

Inverters usually have an overload rating. The time period of the allowable overload rating depends on the time it takes before overheating becomes an issue. A typical overload rating is 150% of nominal load for up to one minute.

The ACPL-C79A accepts full-scale input range of ±300 mV and the data sheet specifications are based on ±200 mV nominal input range. Designers can choose the overload threshold at or in between either of the two figures. Usually the measurement accuracy of the overload current is less stringent than that of the normal operating current. Here, setting the threshold near 300 mV is a good choice. This allows full use of the iso-amp's dynamic input range. However, a threshold set at 200 mV ensures accurate measurement of the overload current. Once the voltage levels are decided, the designer must choose appropriate sense-resistor value according to corresponding current level.

The HCPL-788J includes an additional feature, the ABSVAL output, which can be used to simplify the overload detection circuit. The ABSVAL circuit rectifies the output signal, providing an output proportional to the absolute level of the input signal. This output is also wire OR-able. When three sinusoidal motor phases are combined, the rectified output (ABSVAL) is essentially a DC signal representing the RMS motor current. This DC signal and a threshold comparator can indicate motor overloads before they can damage to the motor or drive.

Overvoltage Detection

The DC bus voltage must also be continuously controled. Under certain operating conditions, a motor can act as a generator, delivering a high voltage back into the DC bus through the inverter power devices and/or recovery diodes. This high voltage adds to the DC bus voltage and puts a very high surge on the IGBTs. That surge may exceed the maximum IGBT collect-emitter voltage and damage them.

The miniature iso-amp (ACPL-C79A) is often used as a voltage sensor in DC bus monitoring applications. A designer must scale down the DC bus voltage to fit the input range of the iso-amp by choosing R1 and R2 values to get an appropriate ratio.