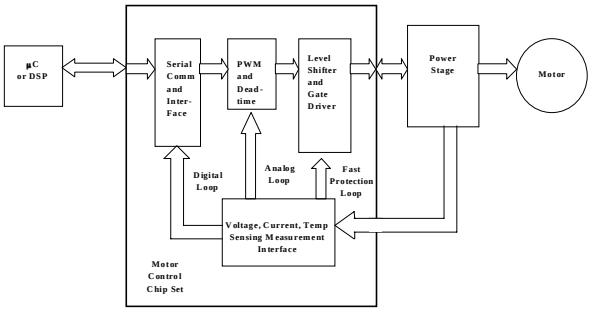
The IR Motor Control Architecture and Chipset

New IR chipset set the architectural standard for motor control system design by partitioning the inverter function as intelligent power management peripheral to the motion system controller.

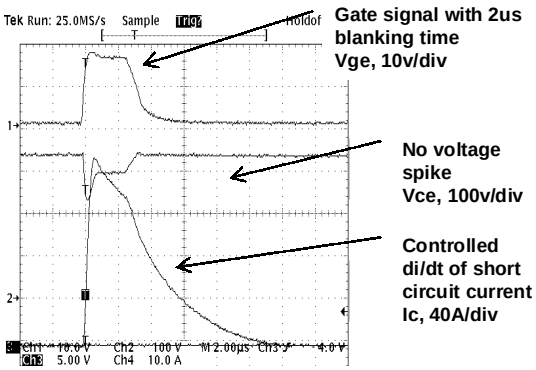
Design of modern motor control system is quite complex and requires deep understanding of control system algorithms, micro-controller and digital signal processor, sensor signal measurement and analog to digital converters, high voltage interface and gate drivers, and output inverter power stage. Traditional methodologies do not efficiently partition the design tasks into well-defined architectural elements with standardized interface protocols. That results in complex and customized designs, high initial product cost as well as high lifetime ownership cost.

International Rectifier is introducing a new architecture for the power management of motor drive inverter. A new chipset family is used to implement this very flexible, versatile and yet performance oriented power management architecture. This chipset sits in between the micro- or DSP controller and the three-phase inverter power stage. Guiding principle behind the design is intelligent partitioning, standardized interface protocol and performance enhancement of the power management functions. The most fundamental concept is treating the inverter as an "intelligent power management peripheral" for the uC or DSP. Control system software is now written at a higher hierarchical level (for example in C language) without the need to program at the bit level for the motor control power management functions such as pulse width modulation (PWM), deadtime generation and compensation, diagnostic and protection, voltage and current measurement interface. High voltage analog and power circuits required to turn the software algorithms into commanding power transfer are integrated within the chipset in concert with the other power management functions. A suite of technologies are used to implement the chipset including mixed signal 0.5um CMOS and high voltage BCDMOS with rating from 600V to 1200V. They can be applied to varieties of applications driving AC or Brushless DC motor for Industrial AC Drives, Industrial Servo Drives, Appliance Drives (Air-Conditioner, Washing Machine, Refrigerator Compressor), Robotics, Electronic Power Steering (12V, 42V), Integrated Starter Alternator (42V), High Reliability Drives (aviation, space). The simplified block diagram for the chipset is shown as follows:



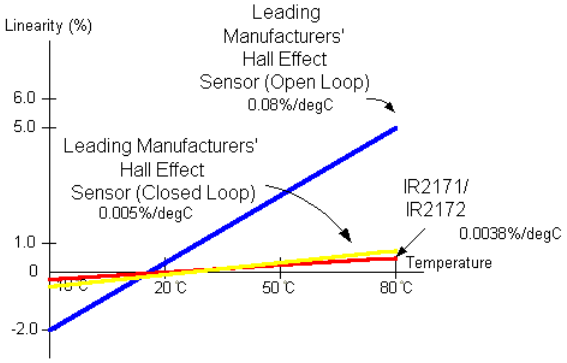
High Voltage Gate Drive

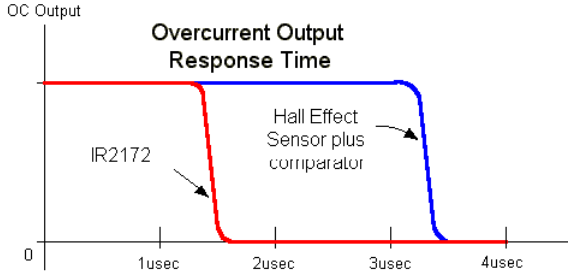
The 3-phase inverter power stage is usually consisting of 3 high side and 3 low side IGBTs or MOSFETs operating from a high voltage DC bus. The bus voltage varies depending on applications but they can range from 12V for automotive to 600V for 230Vac and 1200V for 460Vac industrial drives. Previous methods use discrete opto-couplers to provide the high voltage gate drives to the IGBTs or MOSFETs. High voltage IC technology enables the integration of 3-phase gate driver in a single chip such as the industry standard 600V IR213x and 1200V IR223x product family. The first series of the IR motor control chipset integrates the 600V IR2137 or 1200V IR2237 in the gate driver function. Added features include IGBT de-sat protection and synchronized soft shutdown. The robust protection against short circuit conditions such as line-to-line short, ground fault and shoot through results in controlled di/dt and no voltage spike across the IGBT during short circuit turn off as shown:



Phase Current Measurement

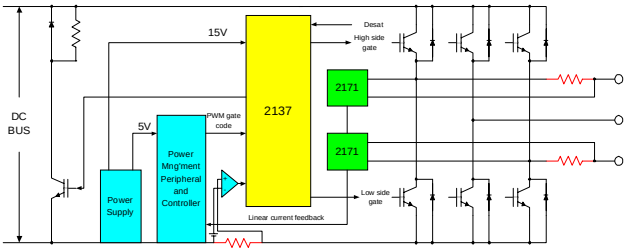
Motor phase current is difficult to measure accurately or with precise linearity over wide current and temperature ranges. Hall effect sensors can be used but they are inherently bulky and costly. Alternatively current sense resistors are used to measure the differential voltage drop across each output phase using opto-coupler or high voltage IC. Linear opto-couplers suffer from linearity drift over temperature range and operating life. The IR motor control chipset uses high voltage ICs such as the 600V IR217x and 1200V IR227x product family. Differential voltage in the range of +/-300mV that sits on top of fast switching common mode voltage up to 600V or 1200V is converted to a ground based PWM output from the IR217x chip. Then the PWM signal is processed using a 12-bit counter having a clock frequency of 120MHz. The temperature drift is canceled by a fast 13-bits division routine that calculates the duty ratio of the incoming PWM signal withdrawing any temperature dependence of the slope. A linearity plot of the current measurement output from the IR2171 or IR2172 over temperature is shown:





Power Management Peripheral

The IR motor control chipset is configured as an intelligent power management peripheral to the uC or DSP. Individual chips in the set are designed to work in an integrated manner. Simplified circuit schematic for the first series in the chipset family is shown:



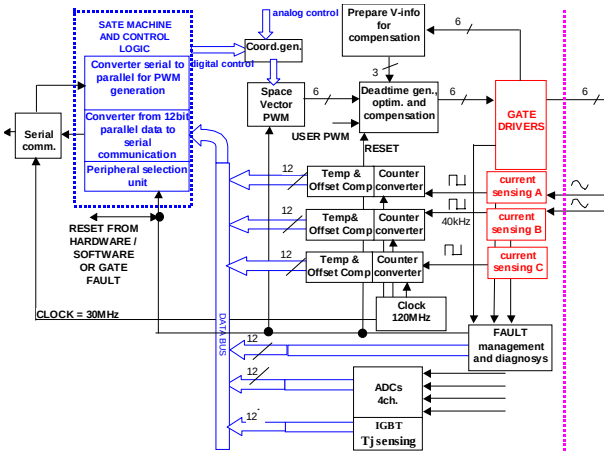
Space Vector Pulse Width Modulator (SVPWM) is built in. Programming of the modulator can be done through different input coordinates introduced through a serial interface:

- auto-generation based on (V,f) information;
- bi-phase (vx,vy);
- two phase of a three-phase system (va,vb);
- polar co-ordinates input.

Sampling frequencies including high frequencies able to replace analog PWM generators are ranging between 3.6kHz and 29.2kHz. Same pulse resolution is maintained at all the sampling frequencies by a special arrangement of the main timer. A special selection of the zero vector is used to reduce switching loss in the inverter power stage.

The deadtime generator resolution is 16.66ns and the maximum deadtime is about 8.4us. A minimal value of 100ns is introduced to avoid delays in signal propagation when no deadtime is programmed.

Programming of the Space Vector Modulator, deadtime generator and current sensing interface are made through a dual-port memory. This is periodically read and/or write by the upper hierarchical level through a well defined serial interface. The overall block diagram is shown below:



IR Motor Control Chipset Roadmap

The concept of the IR motor control chipset is rooted in the idea of considering the inverter as an intelligent power management peripheral to the uC or DSP control. All the detailed power management functions are performed within the chipset and the results are presented in memory locations that are updated periodically in a very transparent way. The upper level control software is greatly simplified by only requiring to look up the data updates to and from the chipset.

The chipset roadmap is evolutionary and allows performance enhancement functions to be added in each new generation of product development while maintaining the standard interface protocol to the system

control. The first series in the chipset family include robust power stage protection, linear current measurement, SVPWM, deadtime generation and system monitoring functions. New development already in the work for the evolving roadmap will add voltage feedback, deadtime compensation, temperature measurement and higher current loop bandwidth.

Another benefit of the chipset is the relatively small size with the implementation using easily integrated technologies in mixed mode CMOS and high voltage BCDMOS. The mechanical integration of the chipset with power stage is greatly simplified. A system demonstration vehicle is built using the popular Econo2 package as the power module. The entire chipset and its support components fit within the dimension of the module easily. This allows the other standard interface protocol to be set up between the power management chipset and the power stage. New development will couple the new functions in the chipset with additional integration of sensor components inside the power module while having well defined pinout standard for the interface protocol.

(I need a picture here for the chipset PCB with the Econo2 module)