International
IOR Rectifier

December 21, 2003 Rev 2.0

IRMCS2011

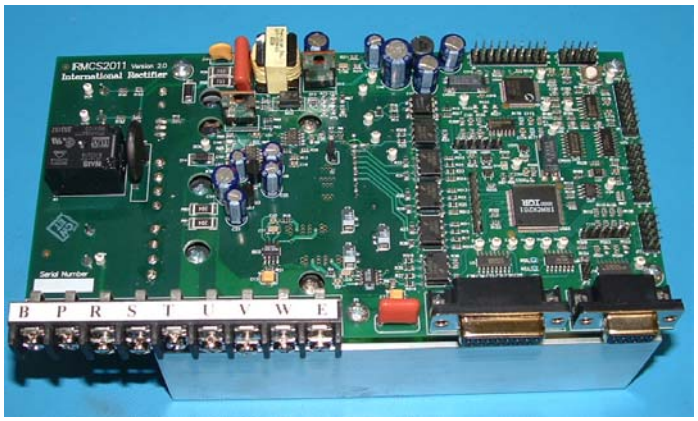
Complete Encoder Based Servo Drive Design Platform iMOTION™ Development System

Features

- **Low cost complete AC servo drive design platform**
- **IRMCK201 IC for complete servo control**
- **Simple design with IR2175 current sensing HVIC**
- **230V/750W maximum output power with 600V/16A advanced Plug-N-Drive™ IGBT module**
- **High bandwidth torque loop response**
- **Flexible drive configuration (PMAC or induction motor)**
- **Quadrature encoder interface**
- **Low cost A/D interface with multiplexer**
- **ServoDesigner™ tool for easy operation**
- **RS232C/RS422 and fast SPI interface (standard)**
- **Parallel interface for microcontroller expansion or debug port**
- **Over-current and ground fault protection**
- **Over-voltage / Under-voltage protection**
- **Dynamic Braking control with brake IGBT/FWD**
- **Discrete I/Os (START, STOP, FAULT, FLTCLR, SYNC, CALIB, PWMEN)**
- **Configuration data retention at power up/down**

Product Summary

Current loop bandwidth (-3dB)	5 kHz(typ)
Speed loop bandwidth (adjustable)	400 Hz(typ)
PWM carrier frequency	70 kHz max
Hardware current loop execution time	6 usec
Enhanced low speed regulation by 1/T algorithm	
Continuous output current	5.0 Arms (750W)
Overload output current	15 Arms
Max SPI comm. speed	6 MHz
Slave SPI configuration	
Max RS232C speed	57.6 kbps



Description

IRMCS2011 is a complete servo drive design platform for AC servo drive applications up to 750W. The system contains the latest advanced motion control IC, IRMCK201, and the ServoDesigner™ software. The complete B/Ms and schematics are provided so that the user can adapt and tailor the design per application needs. The system does not require any software code development due to unique Motion Control Engine implemented in the IRMCK201 IC. User can readily evaluate high performance servo control without spending development effort usually required in the traditional DSP or microcontroller based system. IRMCS2011 contains advanced iMOTION™ chipset such as IR2175 monolithic current sensing ICs and IRAMX16UP60A intelligent power module which enables simple and cost effective motion control design.

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1. Overview

The IRMCS2011 is a design platform for a complete servo drive system based on IRMCK201 IC. The system is based on configurable Motion Control Engine implemented by hardware logics in the IRMCK201. The system has a simple and low cost yet very flexible structure, made possible by advanced IR motion components including the IRAMX16UP60A IGBT module, and IR2175 monolithic current sensing high voltage IC. These components together with IRMCK201 IC simplify hardware construction, and perform complete servo amplifier functions. Since all control logic is implemented in hardware logic as opposed to programmed software, unmatched parallel computation is achieved resulting in high bandwidth torque control.

Despite the fact that technology is based on hardware logic implementation, its design flexibility allows the user to configure different types of motors, position feedback devices, and communication protocols. The system also allows feedforward control in addition to existing PI control.

Design cycle time can be greatly shortened. Unlike a traditional DSP or microcontroller, the architecture is based on configurable register interface, and does not require any programming to complete customization for specific application needs. The user only has to configure the drive using ServoDesigner™ interactive design tool and it takes just a matter of hours instead of months and years.

Once the user become satisfied with function and performance, he can generate his own design using IRMCS2011 schematics and B/Ms.

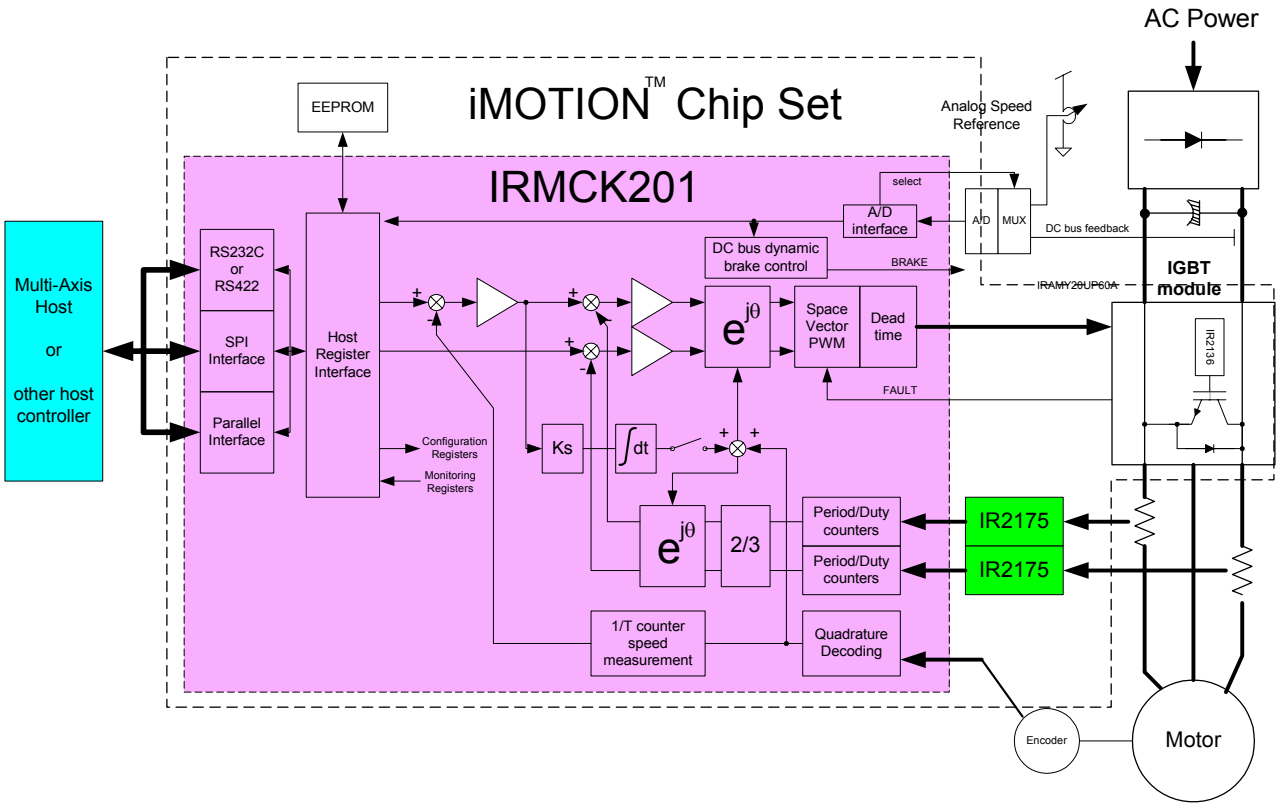


Figure 1. IRMCS2011 System Block Diagram

2. Getting Started

2.1 Safety Precautions

In addition to the precautions listed throughout this manual, you must read and understand the following statements regarding hazards associated with AC servo development system.

ATTENTION: Some ground potential of the IRMCS2011 system is biased to a negative DC bus voltage potential and kept high voltage potential while power is on. When measuring voltage waveform by oscilloscope, the scope ground needs to be isolated. Failure to do so may result in personal injury or death.
Darkened display LED is not an indication that capacitors have discharged to safe voltage levels.

ATTENTION: The IRMCS2011 system contains high voltage capacitors which take time to discharge after removal of main supply. Before working on drive system, ensure isolation of mains supply from line inputs [R, S, T]. Wait three minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death.
Darkened display LED is not an indication that capacitors have discharged to safe voltage levels.

ATTENTION: Only personnel familiar with the drive and associated machinery should plan or implement the installation, start-up, and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

ATTENTION: The surface temperatures of the drive may become hot, which may cause injury.

ATTENTION: The IRMCS2011 system contains ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference applicable ESD protection handbook and guideline.

ATTENTION: An incorrectly applied or installed drive can result in component damage or reduction in product life. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.

2.2 Unpacking and Inspecting

The IRMCS2011 system is shipped with packing materials that need to be removed prior to installation.

ATTENTION: Failure to remove all debris and packing materials, which are unnecessary for system installation, may result in overheating or abnormal operating condition.

After unpacking, check the items. The following hardware pieces are contained in the IRMCS2011 system.

- IRMCS2011 board with integrated heat sink
- Serial RS232C cable with 9-pin D-sub connectors for ServoDesigner™ development tool
- Installation CD

Before you install and start up the system, check if there is any damaged component. In that case, stop proceeding and contact our technical support.

3. Preparing the Motor

3.1 Readily Drivable Motor List

If the motor is one of the following, it can be run immediately without commissioning.

- Sanyo Denki 400W 8-pole servo motor with 2000-pulse encoder (P30B06040DXS00M,)
- Sanyo Denki 750W 8-pole servo motor with 2000-pulse encoder (P30B08075DXS00M)
- Sanyo Denki 1.5kW 8-pole servo motor with 2000-pulse encoder (P20B10150DXS00M)
- Glentek 160W 4-pole servo motor with 2000-pulse encoder (GMB2010-17-E-02100005)
- Glentek 1.0kW 6-pole servo motor with 5000-pulse encoder (GMB3530-24-E-02200109)
- Glentek 1.2kW 6-pole servo motor with 5000-pulse encoder (GMB3530-37-E-02200109)
- Glentek 600W 6-pole servo motor with 5000-pulse encoder (GMB3530-48-E-02200109)
- Pacific Scientific 800W 8-pole servo motor with 2048-pulse encoder (PMB23C-00114-00)
- Reliance Electric 2HP 4-pole induction motor with 1024-pulse encoder (P14A5805)

If any other motor is used, adaptation and re-configuration is required, which can be accomplished using the ServoDesigner™ tool.

3.2 Assembling Encoder Connector

Prepare the connector assembly to the encoder cables.

For permanent magnet motors:

- Assemble 15-pin male D-Sub connector, referring to Figure 2.
- Eleven pins are used: A+ (pin 2), A- (pin 3), B+ (pin 4), B- (pin 5), Z+ (pin 6), Z- (pin 7), HALL_A (pin 10), HALL_B (pin 11), HALL_C (pin 12), 5V(pin 1 or pin 9) and GND (pin 8 or pin 15).
- Make sure that the encoder is a 5V type. If it is not a 5V type, proper modification is required.
- If hall sensors have differential output, connect only positive sides and leave negative sides open.

For induction motors:

- Assemble 15-pin male D-Sub connector.
- Only six pins are used because z-pulse is not necessary for an induction machine. The six pins are: A+ (pin 2), A- (pin 3), B+ (pin 4), B- (pin 5), 5V(pin 1 or pin 9) and GND (pin 8 or pin 15).
- Make sure that the encoder is a 5V type. If it is not a 5V type, proper modification is required.
- Disable Z_pulse by connecting Z+ to GND and Z- to 5V.

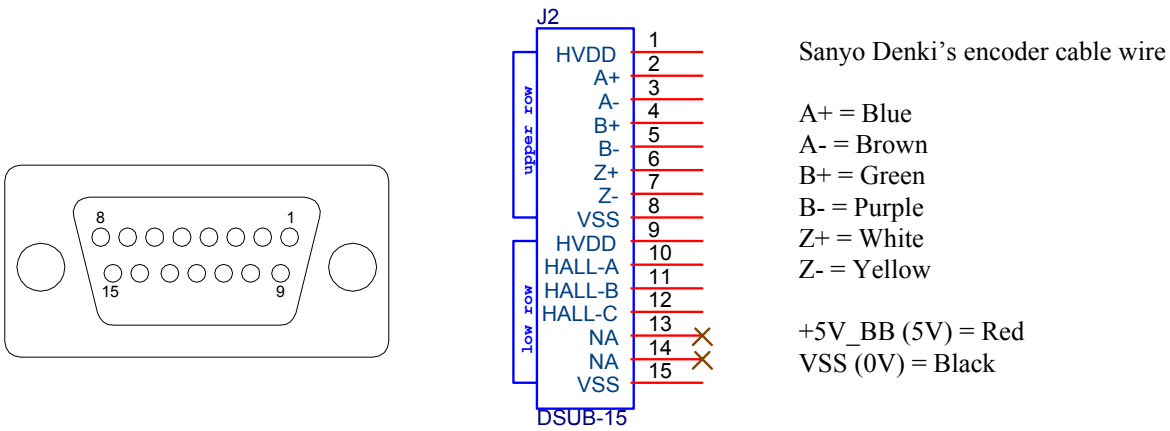


Figure 2. Encoder Interface Connector, J2

3.3 Motor Power Cable

Prepare the motor power cable which has four wires: U, V, W and E (earth ground). Proper size and length of cable should be used.

4. Hardware Installation

4.1 Safety Precautions

ATTENTION: Remove and lock out power from the drive before you disconnect or reconnect wires or perform service. Wait three minutes after removing power to discharge the bus voltage. Do not attempt to service the drive until bus voltage has discharged to zero. Failure to do so may result in bodily injury or death.

ATTENTION: The drive is intended to be commanded by control input that will start and stop the motor. A device that routinely disconnects then reapplies input power to the drive for the purpose of starting and stopping the motor should not be used. Failure to follow this guideline may result in damage of equipment, and/or bodily injury or death.

ATTENTION: Do not connect power factor correction capacitors to drive output terminals U, V, and W. Failure to do so may result in equipment damage or bodily injury.

4.2 Input Power Wiring

Connect AC 115V or single-phase 230V or three-phase 230V power. For single phase 100V-230V AC power, use R and T for connection. For three phase 230V power, use R/S/T for connection. Insert a power contactor switch rated at 250V/30A in series with AC power cables.

B	P	R	S	T	U	V	W	E

Figure 4. Power Connector, J1

If full power rating is needed, use three-phase 230V power. Otherwise output power should be de-rated. Proper size and length of cable should be used.

4.3 Motor Wiring

Connect motor power and ground wires to terminal block J1 of IRMCS2011 board.

B	P	R	S	T	U	V	W	E

Figure 5. Motor Wiring Connection

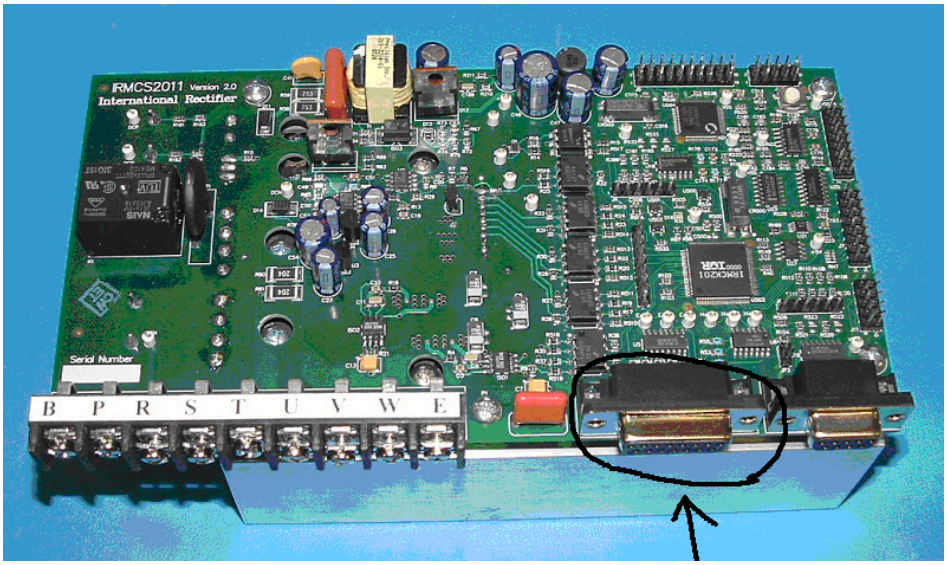
For Sanyo Denki or Glentek or Pacific Scientific motors, the colored wires should be connected to the associated Terminal Block pins of the IRMCS2011 board as shown in **Error! Reference source not found.**.

Sanyo Denki's motor cable wire	Glentek motor cable wire	Pacific Scientific motor cable wire	Terminal block pin
RED	RED (pin A)	BLUE	U
WHITE	BLUE (pin C)	VIOLET	V
BLACK	BLACK (pin B)	BROWN	W
GREEN/YELLOW	GREEN (pin D)	GREEN/YELLOW	E

Table 1. Motor Connections

4.4 Encoder Connection

Plug the encoder connector into J2. Make sure that encoder signals are connected properly. Incorrect connection of encoder signals will result in improper rotor position and/or incorrect communication. The shell of the connector is grounded to the chassis for shield termination.



4.5 RS232 Connection

Connect the serial cable between the computer and J6. Make sure that cable is connected properly. Incorrect connection of serial cable will result in communication error and/or incorrect communication. The shell of the connector is grounded to the chassis for shield termination.

5. Software Installation

The ServoDesigner™ tool is distributed on the CD-ROM. Load the CD into the CD-ROM drive on your PC and double-click “IRMCS2011.exe”. The automated procedure installs all necessary software on your PC. The default location for the installation is “C:\Program Files\Accelerator”.

6. Power-On the System

Apply AC 115V – AC 230V power to the system.
Immediately after power-on, the red LED (surface mount LED located at the right side of the board) will lit on/off indicating the on-board DC bus has been established, and turns to green once configuration data is loaded either from the on board EEPROM or ServoDesigner™ through RS232C.

7. Motion Control Engine

7.1 Motion Control Engine (MCE) -Based Complete Servo Control

Figure 2 shows the detailed algorithm block diagram including various parameters which can be configured through the host register interface.
Closed loop current and velocity control are implemented in the IRMCK201 IC on the IRMCS2011 board. The closed loop current control algorithm is based on a synchronously rotating frame, which is shown in Figure 3. The velocity control is available as an outer loop control of the current control and can be disabled in order to configure torque control mode. Additional configuration allows feedforward control, selection of the position feedback devices, induction machine vector control, and selection of communication protocol.

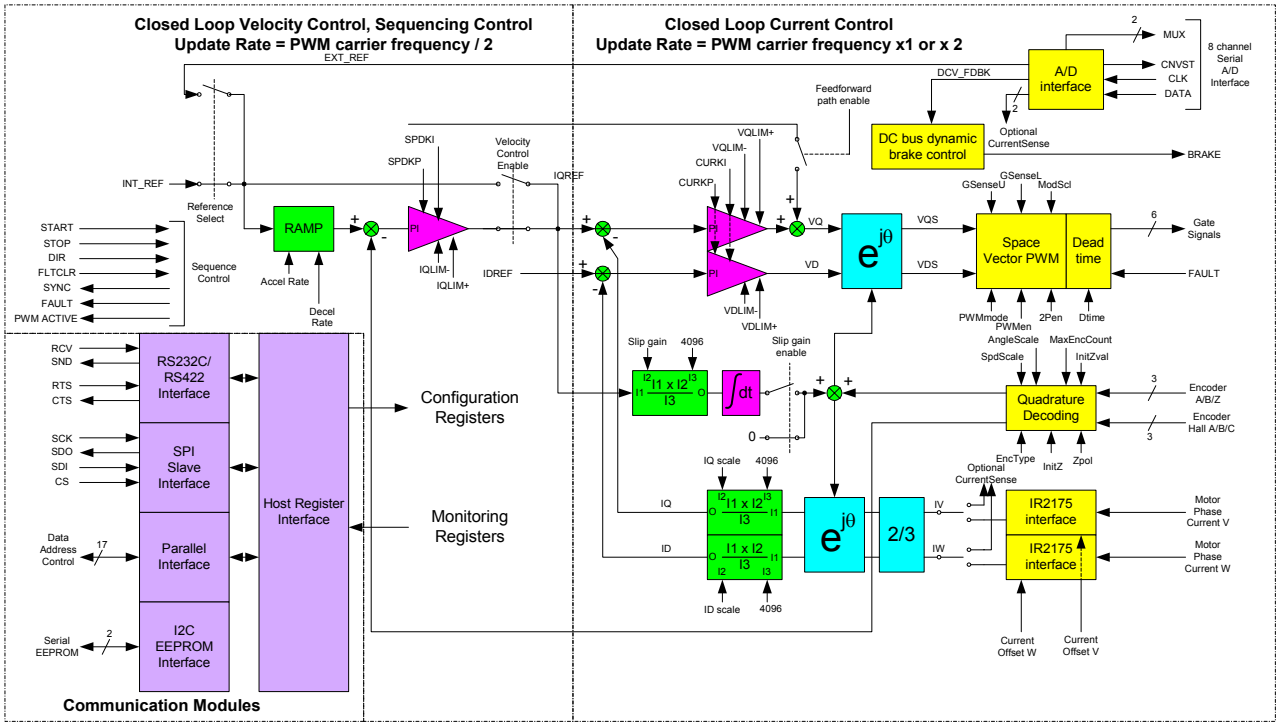


Figure 3. IRMCK201 based Complete Servo Control

8. New Motor Adaptation

New motor can be configured by simple EXCEL spreadsheet. EXCEL spreadsheet template is provided in the shipment with the filename = "IRMCS2011-DriveParams.xls" shown in Appendix.
This spreadsheet facilitates configuration of parameters which need to go into each host registers inside of the IRMCK201 IC. The spreadsheet calculates current feedback/speed feedback scaling, Proportional plus Integral (PI) gains of current and speed regulators, PWM carrier frequency, deadtime,etc, based on simple motor nameplate and published data input. The output of this spreadsheet is text file containing one-to-one corresponding each registers' values. User can use the ServoDesigner™ to read this output into the associated registers.

For detailed operation, please refer to "3.1 Drive Parameter Setup" in IRMCK201 Application Developer's Guide.

Motor Selection :	**1**	**P30B06040DXS00M**
(Type the number here!)		password : 2011

"========== Motor Information ==========="			
(RPM) Rated Speed	**3000**	rpm	
(Lq) L_phase	**0.00644**	H	(line to line Inductance) / 2
(R_Stator) R_phase	**1.4**	ohms/ph	(line to line Resistor) / 2
(Amps) Rated Amps	**2.7**	Arms	
(NLC)No Load Current	**0**	Arms	(necessary for IM)
(Jm) Inertia of Motor	**2.55E-05**	Kg-m2	
(Kt) Torque Constant	**0.533**	N-m/Arms	
(Ke) Voltage Constant	**18.6**	V ln-rms/krpm	voltage is line to neutral rms
Poles	**8**		
(PPR) Encoder PPR	**2000**	pulse/revolution	
Wire-Saving Encoder?	**TRUE**	(TRUE / FALSE)	
"========== Application Information ==========="			
"---------- General ----------"			
Max RPM	**4500**	rpm	
(Vdc_Nom) Nominal Vdc	**310**	Volts	
(OvLoad) Max pu motor current at rated speed	**3**	pu	
"---------- Speed Regulator Tuning ----------"			
Speed Regulator BW	**200**	rad/sec	
Positive Speed Rate limit	**1000**	rpm/sec	
Negative Speed Rate limit	**1000**	sec to rate speed	
Inertia of Load (measured)	**0**	Kg-m2	
SpdLpRate	**2**	1 SpdLoop per this # of CurLoop	
"---------- Current Limits ----------"			
Motoring Limit	**200**	%	

Regen Limit	**200**	%
"---------- Inverter Switching Frequency ----------"		
(fc) Pwm carrier freq	**10**	KHz
Dead_Time	**0.5**	usec
" ---------- Current Regulator Tuning ---------- "		
(Ireg_BW) Current Reg BW	**2500**	rad/sec
"============== Advance Information (Platform fixed) ==============="		
Note: Below values are fixed for IRMCS2011 platform however can be changed for other platform		
(Clk) IRMCK201 clock freq	**33.333**	MHz
DC Bus Scaling (Vdc_Scl)	**8.1875**	cts/Volt
I_Torque (I_Trq_Rated)	**4095**	cts for rated Amps
(Mod_Pk) - U_Alpha U_Beta max linear modulation	**2355**	Cts
" ---------- Desired Speed feedback Scaling ---------"		
(Spd_Scale)	**16384**	cts/(Max RPM)
" ---------- Current Feedback Scaling ----------"		
Current Shunt Resistor	**10**	mOhm
Max H/W Current	**26**	Apeak
"================== Commutation Information ==================="		
Angle of Z-pulse (based on UV line to line voltage)	**272**	degree
Mid Angle when Hall CBA is 001	**120**	degree
Mid Angle when Hall CBA is 010	**240**	degree
Mid Angle when Hall CBA is 011	**180**	degree
Mid Angle when Hall CBA is 100	**0**	degree
Mid Angle when Hall CBA is 101	**60**	degree
Mid Angle when Hall CBA is 110	**300**	degree

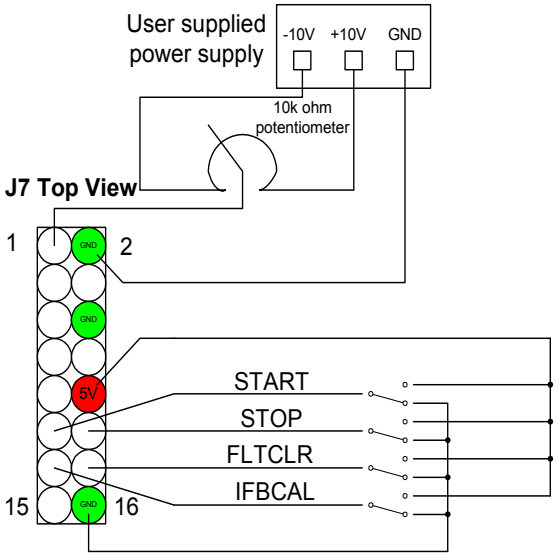
Figure 8 EXCEL Spreadsheet inputs

9. Appendix

9.1 External I/O

Connect External I/O Connector (J7) as needed. All inputs are 5V tolerant and high true logic.

Pin definition



Pin 1: Analog input (+/-10V)
Pin 2: Analog GND
Pin 3: N/A (open)
Pin 4: N/A (open)
Pin 5: N/A (open)
Pin 6: Digital GND
Pin 7: FAULT status output (3.3V when FAULT)
Pin 8: SYNC status output (3usec width of active low pulse at every carrier frequency period)
Pin 9: PWMACTIVE output (3.3V when PWM active)
Pin 10: +5V
Pin 11: START input (high to activate)
Pin 12: STOP input (high to activate)
Pin 13: Ifb offset calibration input (high to activate)
Pin 14: Fault Clear input (high to activate)
Pin 15: N/A (open)
Pin 16: Digital GND

Figure 6. J7 Connector connection

Step 6.
Connect the RS232C cable between 9-pin D-sub connector J6 and PC.

9.2 RS232C Connector

IRMCS2011 has one serial RS232C connector (J6) on the board. The connector is D-sub 9 pin standard PC female connector and directly connectable to PC serial port. As shown in Figure 9, pin2 is send-signal and pin3 is receive-signal, and both are 10V signal level. The baud rate is fixed at 57.6kbps. The signal format is 8bit, no parity, 1 stop bit configuration.

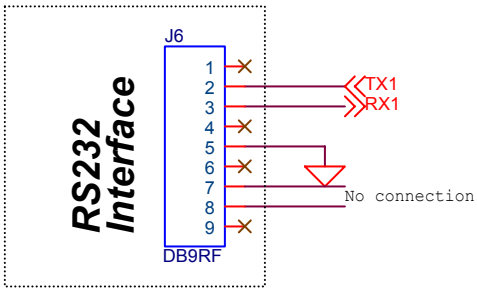


Figure 9. RS232C connector

9.3 Parallel Interface Port

IRMCS2011 provides an 8bit parallel interface port to facilitate microprocessor interface. Interface is generic and able to interface most common 8bit parallel interface such as MCS8051, some Motorola 8bit uP, MicroChip, etc. Figure 11 shows the connection diagram. The connector, J5, is an 2-by-10 header connector pins.
Each signal is 3.3V level and data bus is multiplexed. Table 1 summarizes each signal definition.

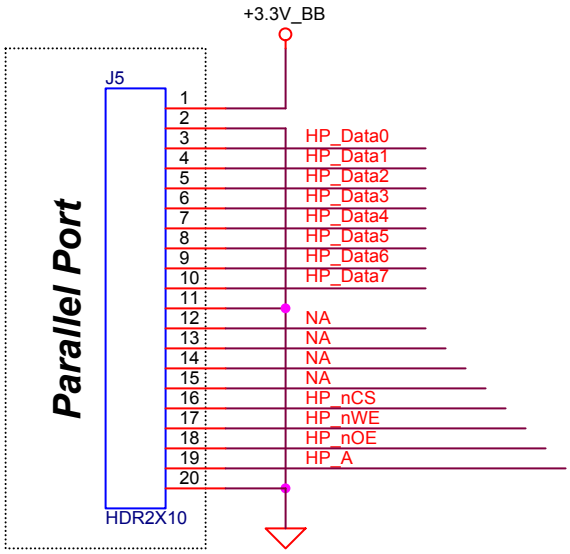


Figure 11 Parallel Interface Port

Signal	I/O[1]	Description
HP_nCS	I	Active low Host Port Chip Select
HP_nOE	I	Active Low Host Port Output Enable
HP_nWE	I	Active low Host Port Write Enable
HP_A	I	Host Port Register Address. 1 = Address register, 0 = Data Register
HP_Data	I/O	Bidirectional Host Port data bus

Table 2. Microprocessor Interface Module Signal Definitions

Figures 12 and 13 show detailed timing requirements for register read and write operations depending on the type of microprocessor (Intel or Motorola type). All values are in nanoseconds. The data bus output is activated by the logical combination (!nCS && !nOE && new), which allows read and write operations to be either nWe/nOE (Intel) or nCS (Motorola) driven.

Row		Name	Min	Max	Comment
1	C	TsuADDR	10		HP_A to HPnCS or HP_nWE (which ever occurs last) low setup time
2	C	TsuData	0		HP_D to HPnCS or HP_nWE (which ever occurs last) low setup time
3	C	Tpw_nCSnWE	60		Minimum pulswidth for nCS and nWE
4	C	ThData	60		Minimum data hold time from HP_nWE or HPnCS (whichever occurs last) low
5	C	ThAddr			Minimum address hold time from HP_nWE or HPnCS (whichever occurs last) low
6	D	Tacc	0	35	HP_nCS or HP_nOE (whichever occurs last) to Data access time
7	D	ThData	0	35	HP_nCS or HP_nOE (whichever occurs last) to Data invalid/Hi-

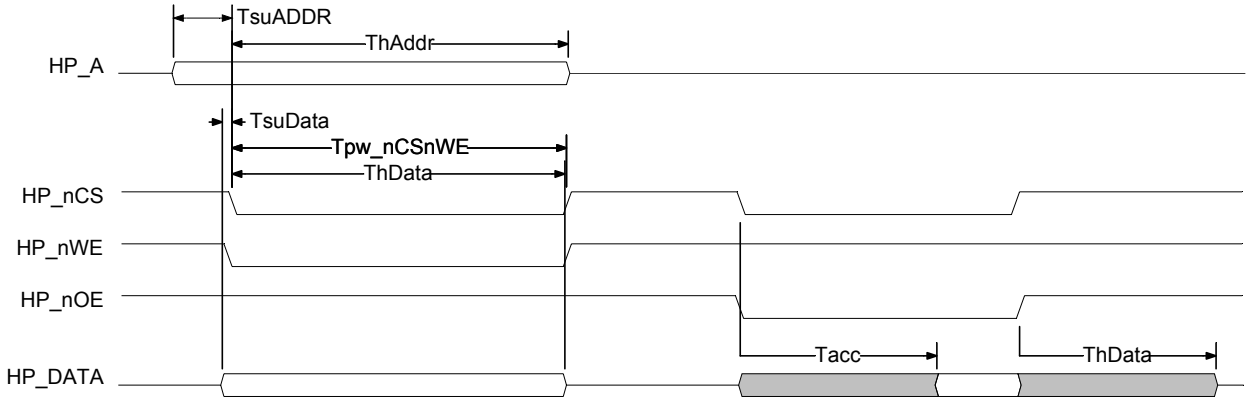


Figure 12. Register Write/Read Timing (Intel)

Row		Name	Min	Max	Comment
1	C	TsuADDR	10		HP_A to HPnCS low setup time
2	C	TsuData	0		HP_D to HPnCS low setup time
3	C	Tpw_nCSnWE	60		Minimum pulswidth for nCS
4	C	ThData	60		Minimum data hold time from HPnCS low
5	C	ThAddr			Minimum address hold time from HPnCS low
6	D	Tacc	0	35	HP_nCS to Data access time
7	D	ThData	0	35	HP_nCS to Data invalid/Hi-Z

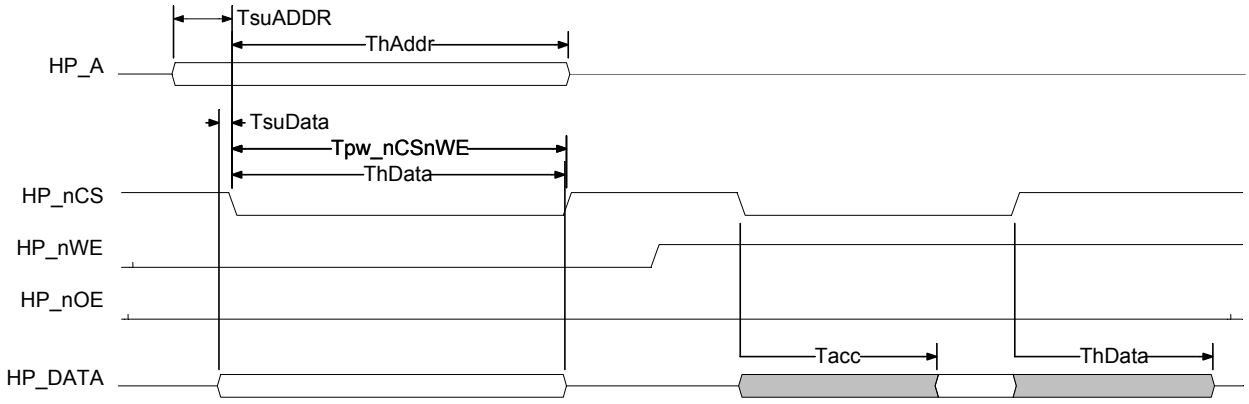


Figure 13. Register Write/Read Timing (Motorola)

10. Specifications

T_C=25°C unless specified

Parameters	Values	Conditions
Input Power		
Voltage	115V-230Vrms, -20%, +10%	
Frequency	50/60 Hz	
Input current	7A rms @nominal output	TA=40°C, RthSA=1.0 °C/W
Input line impedance	4%~8% recommended	
Output Power		
Watt	750W continuous power	Vin=230V AC, f_{PWM}=10kHz, f_O=60Hz, T_A=40°C, RthSA=1.0 °C/W
Current	5.0 Arms nominal, 15 Arms Overload	ZthSA limits ΔTC to 10°C during overload
Host interface (SPI)		
SCLK,CS,MISO,MOSI, SYNC	3.3V logic level	Isolated, maximum 6MHz
Host interface (RS232C/422)		
Tx, Rx	10V	Maximum 57.6k bps, single ended, configurable for RS422 up to 1Mbps
Host interface (Parallel Port)		
HP_nCS, HP_nOE, HP_nWE, HP_A, HP_DATA[8]	3.3V	8 bit parallel interface compatible with 8051, MicroChip, other uP.
D/A		
8 bit 4 Channel	0-3.3V output	Output is buffered with 4mA drive capability
A/D		
12 bit 2 channel	±10V for reference input, 5V for DC bus input	4 channel additional input available (optional)
Discrete I/O		
Input	4 bit, START, STOP, FLTCLR, IFBCAL	5V tolerant, Isolated, Active High logic
Output	3 bit, PWMACTIVE, FAULT, SYNC	
Current feedback		
Current sensing device	IR2175, direct interface	
Resolution	10 bit (7.5 nanoseconds counting resolution)	133 MHz internal IRMCK201 clock
Latency	8.3 usec	IR2175 PWM output (130 kHz)
Protection		
Output current trip level	35A peak, ±10%	
Ground fault trip level	35A peak, ±10%	
Over-temperature trip level	110°C, ±5%	Case temperature
Short circuit delay time	2.5 usec	line-to-line short, line-to-DC bus (-) short
DC bus voltage		
Maximum DC bus voltage	400V	Should not exceed 400V for > 30 sec
Minimum DC bus voltage	120V	VCC=15V ± 10%,VDD=5V ± 5%
Encoder Interface		
Incremental encoder	Maximum 2 MHz	All differential signals are converted to single ended signals including index pulse
Hall A/B/C initialization	Programmable wire saving/dedicated A/B/C	
Power Module		
IRAMX16UP60A 3-phase HVIC	6 IGBT/FRED + IR2136 gate driver, integrated overcurrent/overtemp protection	Bootstrap power supply for high side circuit
System environment		
Ambient temperature	0 to 40°C	95%RH max. (non-condensing)

Table 2. IRMCS2011 Electrical Specification

International
IOR Rectifier

IR WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, Tel: (310) 252-7105
http://www.irf.com

Data and specifications subject to change without notice.

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