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ITC132 High Voltage Micro to Motor Interface

By Bill Lucas and Warren Schultz

An IGBT power stage that is designed to run 3 phase AC Induction motors with input signals from an ASB124 Motion Control Development Board is presented here. It is intended to facilitate code development for the 68HC908MR24. Power ratings include motors up to 1 Horsepower and DC bus voltages up to 380 volts.

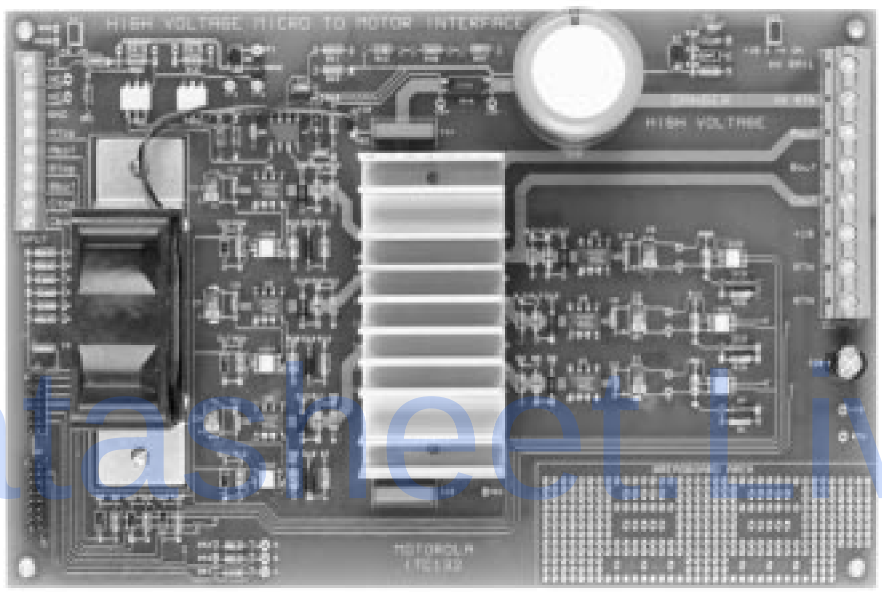

Figure 1. ITC132 — High Voltage Micro to Motor Interface

CAUTION!

ITC132 motor control development boards are capable of operating at dangerous voltages and capable of supplying dangerous amounts of power to rotating machines. To facilitate safe operation, input power for the High Voltage Rail should come from a current limited DC laboratory power supply. Before moving scope probes, making connections, etc., it is generally advisable to power down the high voltage supply. When high voltage is applied, using only one hand for operating the test setup minimizes the possibility of electrical shock. Operation in lab setups that have grounded tables and/or chairs should be avoided. Wearing safety glasses, avoiding ties and jewelry, and using shields are also advisable.

EVALUATION BOARD DESCRIPTION

A summary of the information required to use systems development board number ITC132 is presented as follows. A discussion of the design appears under the heading Design Considerations.

Function

The evaluation board shown in Figure 1 is designed to provide an optically isolated interface between microcomputers and induction motors up to 1 horsepower. It accepts 6 logic inputs which control 3 IGBT Half–Bridge outputs, and is arranged such that a logic ZERO at the input turns on the corresponding power transistor. The inputs are directly tied to opto isolator input diodes, and require an ability to sink 25 mA. This type of configuration is applicable to pulse width modulated (PWM) systems where the PWM signal is generated in a microcomputer, digital signal processor, or other digital system. It is suitable for driving induction motors up to 1 HP off DC bus voltages up to 380 volts. In addition to controlling the motor, current sense, bus voltage, and temperature feedback signals are provided. This board is designed to interface directly with Motorola ASB124 motion control development boards.

Electrical Characteristics

The following electrical characteristics apply to operation at 25 degrees Celsius, and unless otherwise specified, HV Rail = 320 VDC.

Table 1. Electrical Characteristics

Characteristic	Symbol	Min	Typ	Max	Units
DC Rail Voltage	HV Rail	12		380	Volts
Gate Drive Supply Voltage	+18 V	16.2		19.8	Volts
Logic Supply Voltage	+5 V	4.75		5.25	Volts
Peak Phase Current	I_{PK}			10	Amps
Continuous Phase Current	I_M			5	Amps
Input Current @ V_{IN} = 0 V	I_{in}			–25	mA
Quiescent Current +5 V +18 V HV Rail	I_{CC}		 25 125 1		 mA mA mA
Bus Current Sense Voltage	I_{sense}		250		mV/A
Temperature Sense Voltage	V_{temp}		.65		Volts
Bus Voltage Sense Voltage	V_{bus}		5		mV/V
Power Dissipation	P_{DISS}			50	Watts

Content

Board contents are described by the following schematic and parts list. A pin by pin circuit description follows in the next section.

Table 2. Parts List

Item	Quantity	Reference	Part
1	6	C1, C3, C5, C7, C9, C11	22 μF SMT
2	8	C2, C4, C6, C8, C10, C12, C18, C21	.1 μF Ceramic
3	1	C13	470 μF, 450 VDC
4	2	C14, C15	.022 μF
5	3	C16, C17, C19	.O1 μF
6	1	C20	470 μF, 35 VDC
7	1	C22	.33 μF Ceramic
8	1	Q1, D1, Q2, D2, Q3, D3, Q4, D4, Q5, D5, Q6, D6	MHPM6B10A60D
9	6	D7, D10, D13, D16, D19, D22	MUR1100E
10	7	D8, D11, D14, D17, D20, D23, D26	1N914
11	6	D9, D12, D15, D18, D21, D24	MBR160
12	2	D25, D27	MV57124A (RED LED)
13	6	FEET	
14	6	ISO1, ISO2, ISO3, ISO4, ISO5, ISO6	HCPL0453
15	2	ISO8, ISO7	MOC8106
16	1	Q7	MPSA06
17	1	Q8	2N3904
18	6	R1, R7, R13, R19, R25, R31	2.2 OHMS
19	6	R2, R8, R14, R20, R26, R32	5.6K
20	11	R3, R9, R15, R21, R27, R33, R48, R52, R53, R54	100
21	7	R4, R10, R16, R22, R28, R34, R41	10K
22	6	R5, R11, R17, R23, R29, R35	22
23	6	R6, R12, R18, R24, R30, R36	180
24	2	R37, R40	390K
25	1	R38	1.5K
26	1	R42	3.9K
27	4	R39, R43, R50, R51	270
28	2	R44, R49	820
29	1	R45	220
30	1	R46	.01
31	1	R47	10
32	4	TP1, TP2, TP3, GND	TEST POINTS
33	6	U1, U2, U3, U4, U5, U6	MC33153
34	1	U7	MC33072
35	4	LARGE SCREW TERMINAL (DOUBLE)	
36	1	14 PIN RIBBON CONNECTOR	
37	1	16 PIN RIBBON CONNECTOR	
38	5	MEDIUM SCREW TERMINAL (DOUBLE)	
39	1	ITC132 PC BOARD	
40	1	HEAT SINK	AAVID 61010 (1.6″)

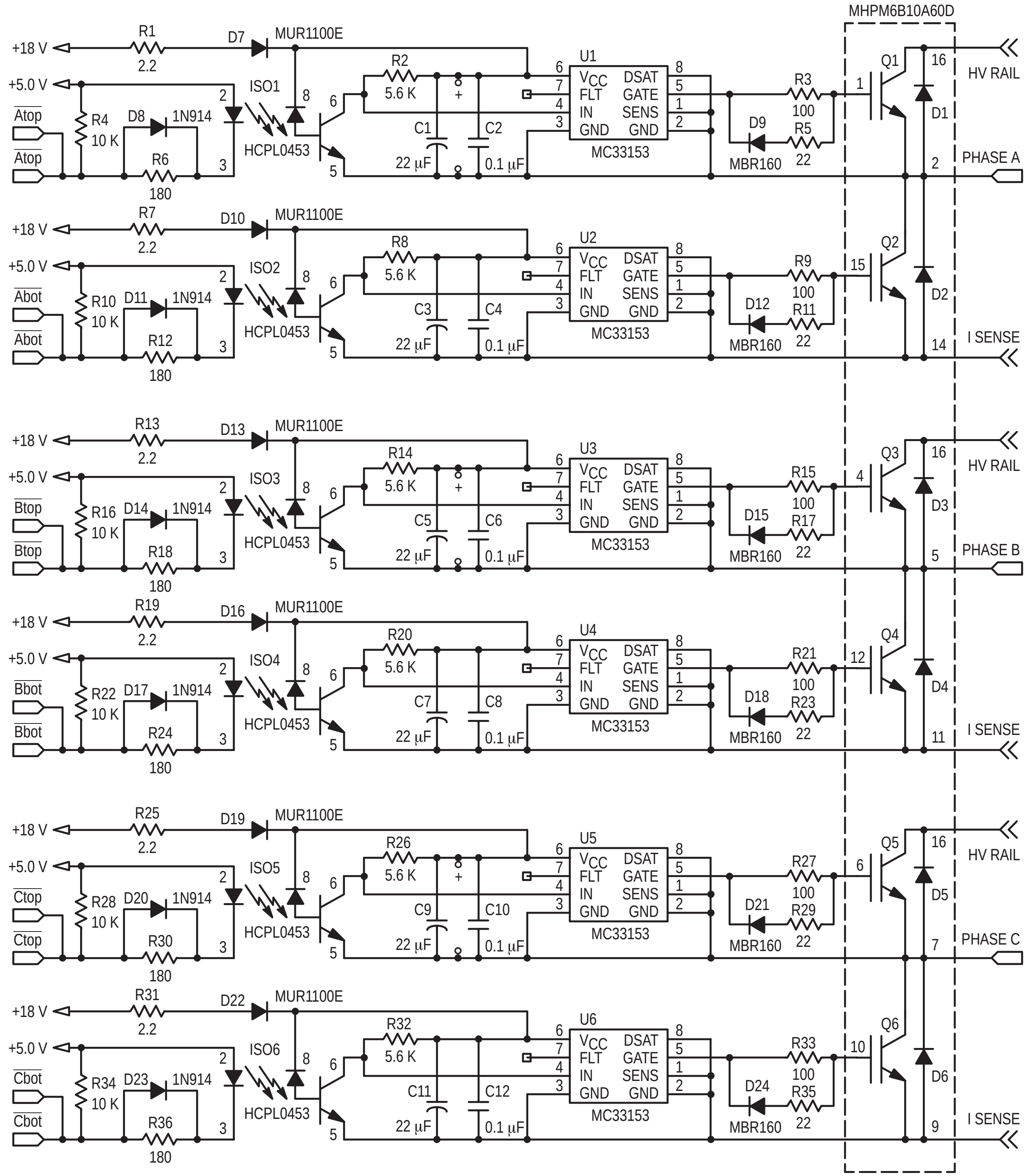

Figure 2. Schematic

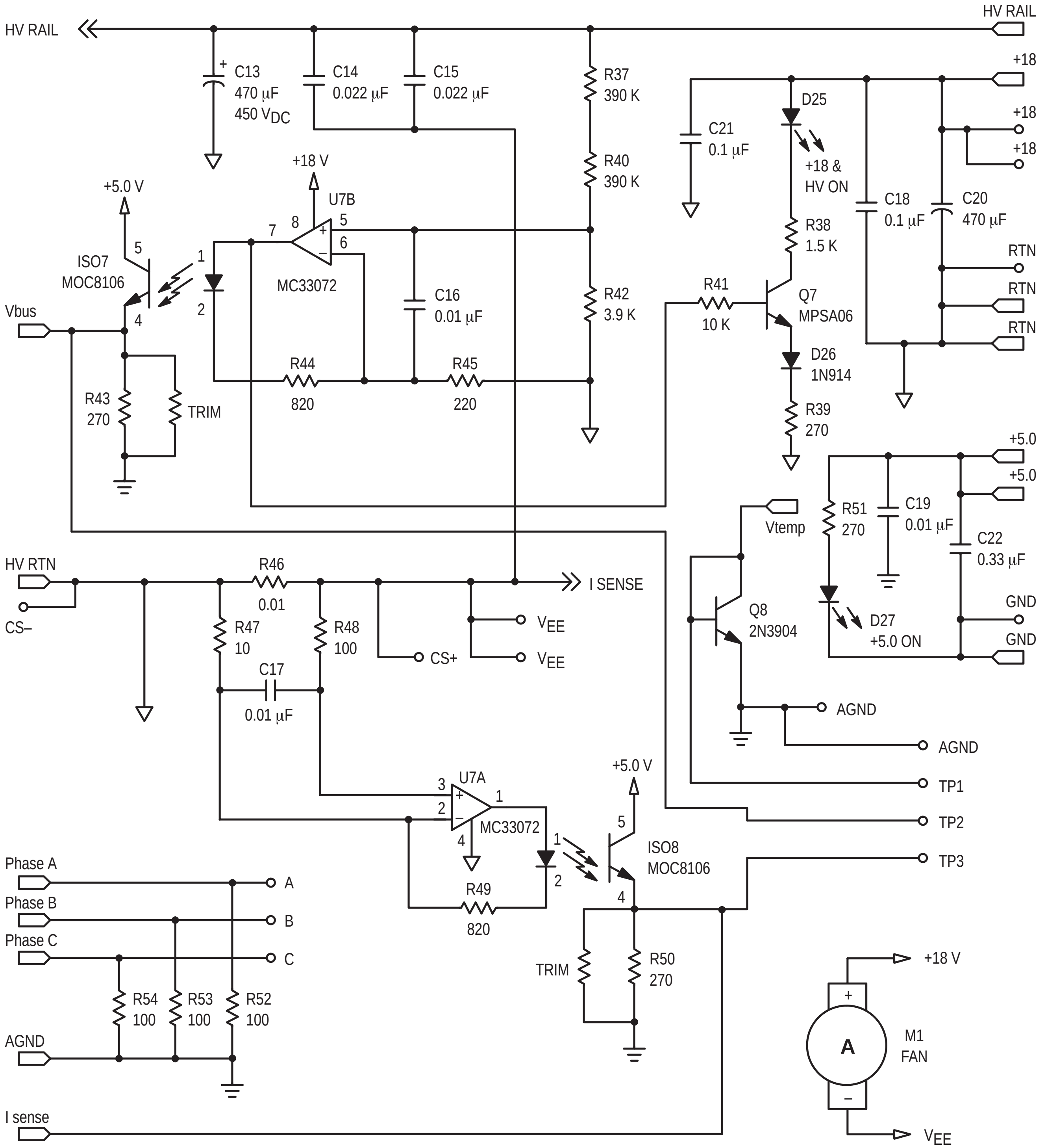

Figure 3. Schematic

Pin By Pin Description

Inputs and outputs are grouped into four connectors. Two connectors are provided for inputs, +5 V, and ground. One consists of screw terminals and the other is for ribbon cable. Either can be used, they are wired in parallel. Outputs to the motor, +18 V, and the High Voltage Rail are supplied on a large screw connector. Returns for the High Voltage Rail and +18 V are also on this connector. Feedback signals are grouped together on a separate ribbon cable connector. In addition, two through hole pads have been placed immediately adjacent to R46 for easy access to the current feedback resistor. Ribbon connector pinouts are shown in Figure 4.

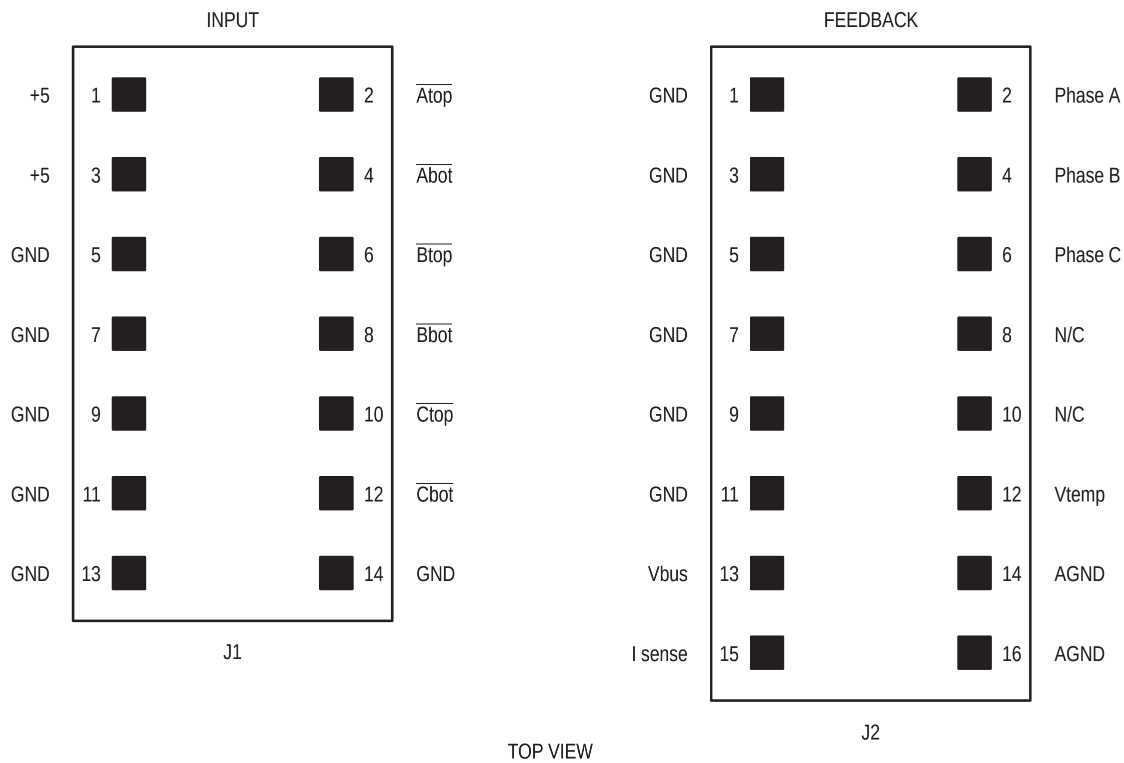

Figure 4. Connector Pinouts

Inputs:
Inputs $\overline{\text{Atop}}$, $\overline{\text{Abot}}$, $\overline{\text{Btop}}$, $\overline{\text{Bbot}}$, $\overline{\text{Ctop}}$, and $\overline{\text{Cbot}}$ are logic inputs. A logic 0 turns on the input's corresponding output transistor, i.e., a logic 0 applied to input $\overline{\text{Atop}}$ turns on output transistor Atop, etc. Logic levels are standard 5 volts, with sink currents that are typically 20 mA. They are pulled up to +5 volts with 10K ohm resistors. Therefore, in the absence of any inputs all output transistors are turned off.

+5:
5 volt power is supplied along with input signals from a control board. It is included on the input connectors for this reason.

GND:
The input connectors contain a ground that is common to the controller's digital ground. It is labeled GND.

HV RAIL:
HV RAIL is the motor power connection. It is intended for use with current limited, line isolated, laboratory power supplies. Acceptable input voltage range is +12 to +380 VDC. It is located at the top of the output connector.

HV RETURN:
HV RETURN is the power supply return for the motor power supply HV RAIL.

+18:
+18 is the gate drive supply. Its tolerance is 16.2 to 19.8 VDC.

RTN:
Two terminals on the output connector are labeled RTN. They are connected together, either one may be used as the +18 volt gate drive supply's return. The other can be used for instrument grounds. These terminals are common to the motor power supply return, HV RETURN, but do not have its current carrying capability. They should not be used for connecting the motor power supply.

Motor Outputs:
Motor output terminals are labeled Aout, Bout, and Cout. They can be used to drive a 3 phase induction motor, 3 phase brushless DC motor, a reversible brush DC motor, or 3 brush DC motors unidirectionally.

Isense:
Isense is a current sense feedback voltage that appears on pin 15 of connector J2. It is derived from a .01 ohm low inductance surface mount sense resistor that is in series with the ground return. The voltage across this resistor is opto isolated and amplified with a nominal gain of 25. Isense, therefore, represents return current with a scale factor of approximately 250 mV/Amp. This signal is isolated with a simple open loop opto coupler, and is therefore not particularly

accurate. A spot on the board adjacent to R50 is provided to trim this output. Software trim techniques can also be used to improve accuracy.

Vbus:
Vbus is a bus voltage feedback signal that appears on pin 13 of connector J2. It is derived from the High Voltage Rail and like Isense is isolated with an open loop opto coupler. It also has provision for a trim resistor, which is located adjacent to R43.

Vtemp:
A temperature output signal derived from a forward biased diode's V_F appears on connector J2 at pin 12. The diode, in transistor Q8, is mounted such that it measures ambient temperature. Two tests points immediately adjacent to Q8 are intended to make it easy to remove and reconnect with a twisted pair of wires. Connected to a twisted pair, Q8 can be placed on the heat sink or motor.

Phase Voltage Feedback:
Phase voltage feedback signals Phase A, Phase B, & Phase C are also included on feedback connector J2. They are located on pins 2, 4, and 6, and terminated with resistors 52, 53, and 54. This board does not provide any signals to these pins. It does provide a solder pad for each phase, labeled A, B, & C, which make it convenient to wire circuitry from the breadboard area to these points. The breadboard area has hole patterns in which 2 LEM LA 25–NP current sensors will fit.

AGND:
A separate ground is provided for the analog signals. It is labeled AGND. AGND and GND are tied together on ASB124 control boards. If a different input source is used, it may be necessary to tie GND & AGND together. Pads for that purpose are located immediately to the left of the +5 V indicator light.

Test Points TP1–TP3:
Test points TP1, TP2, & TP3 provide access to feedback signals for Temperature, Motor Bus voltage, and Motor Bus current. TP1 is connected to the forward biased diode that is used for measuring temperature. Its ground is the analog ground AGND. TP2 is connected to the opto coupled output signal for Motor Bus voltage, and TP3 is connected to the opto coupled output signal for Motor Bus current. Both are also referenced to AGND.

APPLICATION EXAMPLE

An application example shown in Figure 5 illustrates system connections to an ASB124 control board and an induction motor. This arrangement can be run stand alone, or the ASB124 can be connected to an MMDS or MMEVS system for code development. The two boards are designed such that the Drive and Feedback ribbon connectors line up. Cables are supplied with the ASB124 board. Once they are plugged in it is only a matter of connecting power supply and motor leads to get a system up and running. It is important to note that the HV RAIL motor power input is a positive DC voltage that is intended to come from a current limited laboratory power supply.

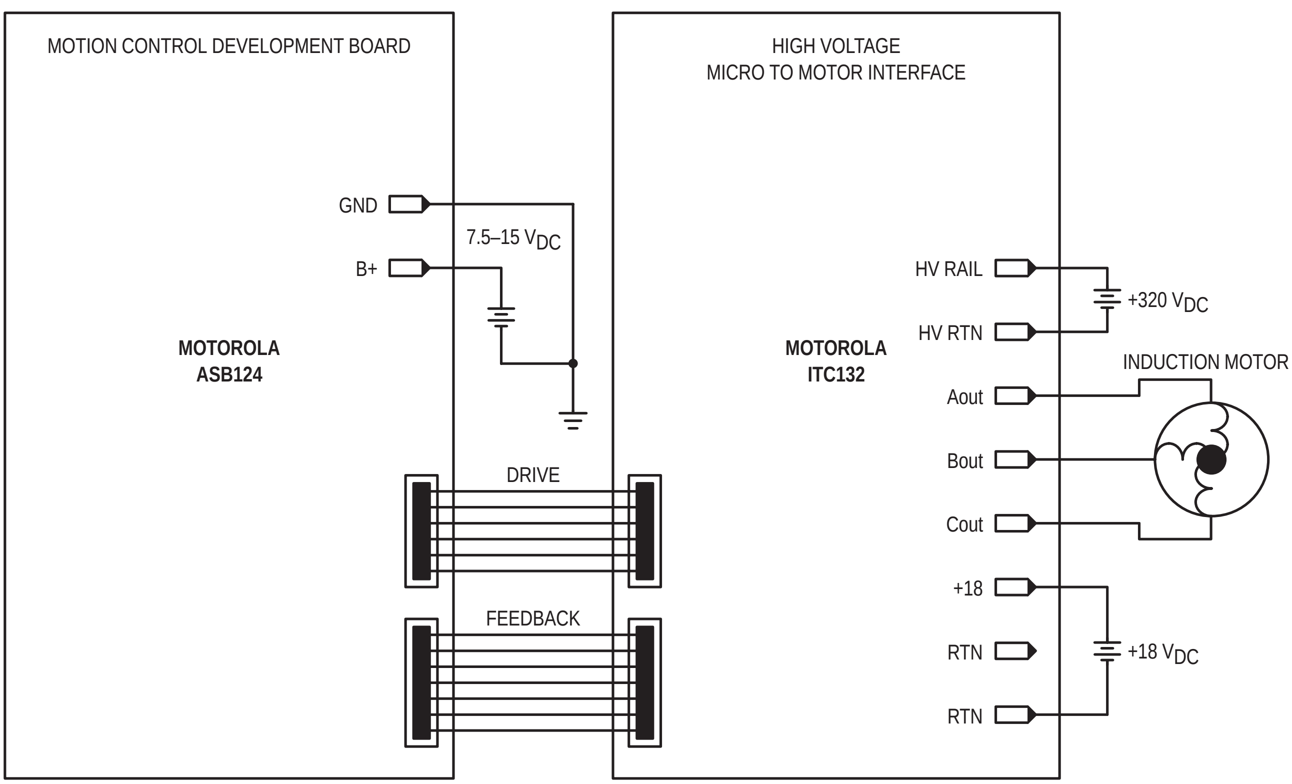

Figure 5. Application Example

An important application's consideration occurs at power up and power down. When the controller's power is off, all of its outputs look like logic lows. In order not to turn–on all six IGBT's simultaneously, it is necessary to avoid completely powering an ITC132 power stage when its controller is unpowered. This is accomplished by supplying the +5 volts that powers the opto inputs from the controller. On ASB124 controllers, this +5 volts is switched off at reset in order to disable ITC132 power stage inputs when power to the controller is not present.

DESIGN CONSIDERATIONS

A simplified schematic of one phase is illustrated in Figure 6. Top and Bottom inputs are opto coupled to inverting gate drivers. This arrangement isolates the inputs from the high voltage power stage, making it suitable for use with microcomputer development tools. It also facilitates board layout and improves noise immunity, since each gate drive can be returned directly to the emitter of its corresponding IGBT. To make things simpler, the IGBT's have a 6 volt gate threshold, making negative gate bias unnecessary. The MC33153 gate drivers have an undervoltage lockout that is designed for the 6 volt threshold.

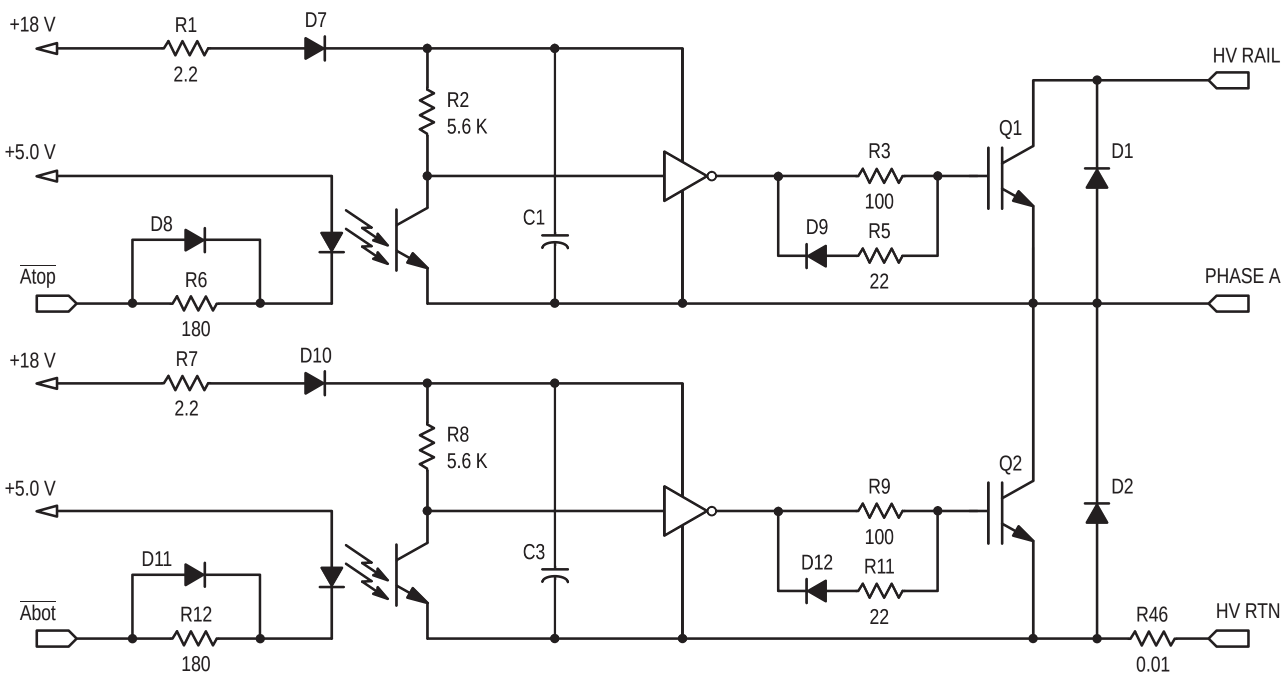

Figure 6. Phase A — Simplified Schematic

From a systems point of view, using opto couplers for both top and bottom gate drives is a very effective strategy for minimizing design time. Even though in many applications opto's are not necessary for the lower half–bridge gate drives, they are very effective at keeping conducted noise from microcontrollers. Since it is noise management that typically takes the most design time, the improved noise robustness of an opto coupled topology can get products to market more quickly.

To further improve noise robustness, several components in addition to opto couplers are used. Referring again to Figure 6, diodes D8 & D11 hold the opto's off with a lower impedance when the inputs are high. Resistors R1 & R7 protect the 18 volt gate drive supply from di/dt induced voltage transients. Although unnecessary for rectification, diode D10 serves the same function on the lower gate drive. Between the driver output and IGBT gates, two resistors and a diode are used instead of a single gate drive resistor. The additional components allow turning the IGBT's on slower than they are turned off. Due to the characteristics of the freewheeling diodes, this arrangement produces less noise than a single resistor. In situations where either layout or freewheeling diode softness characteristics have not been optimized, it is also advisable to add a Schottky diode between the MC33153's output and ground pins.

The upper gate drive bootstrapped power supply has a 22 µF surface mount storage capacitor. This value has been chosen for Induction motor drives that use sine wave or third harmonic pulse width modulation. Space vector modulation and Brushless DC motor drives will work better with larger storage capacitors. Pads are provided on the board for adding larger capacitors if they are needed.

CONCLUSION

The ITC132 High Voltage Micro to Motor Interface is part of a motor control tool set that significantly reduces design and development time. It accepts signals from an ASB124 Motion Control Development Board, and provides a 3 phase power output that is capable of running motors up to 1 horsepower.

NOTES

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