Honda IMA Inverter to drive an eAssist motor

Investigation by Chaz Fisher

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This file documents my reverse engineering findings of the Honda IMA Inverter, P/N 1B100-RMX-A08. I am deeply indebted to the members of the DIY Electric Car forum, especially Tomdb and coleasterling, who did most of the investigations and took numerous pictures of their work. This file should be considered a supplement to Tomdb's pdf file, posted in the thread: https://www.diyelectriccar.com/threads/honda-ima.163650/

This investigation culminated in operating a GM eAssist motor from a 2012 Buick LaCrosse, using a controller based on Johannes Huebner's OpenInverter Controller, v2. Further descriptions of this testing are included in this file.

**Mainboard Layout**

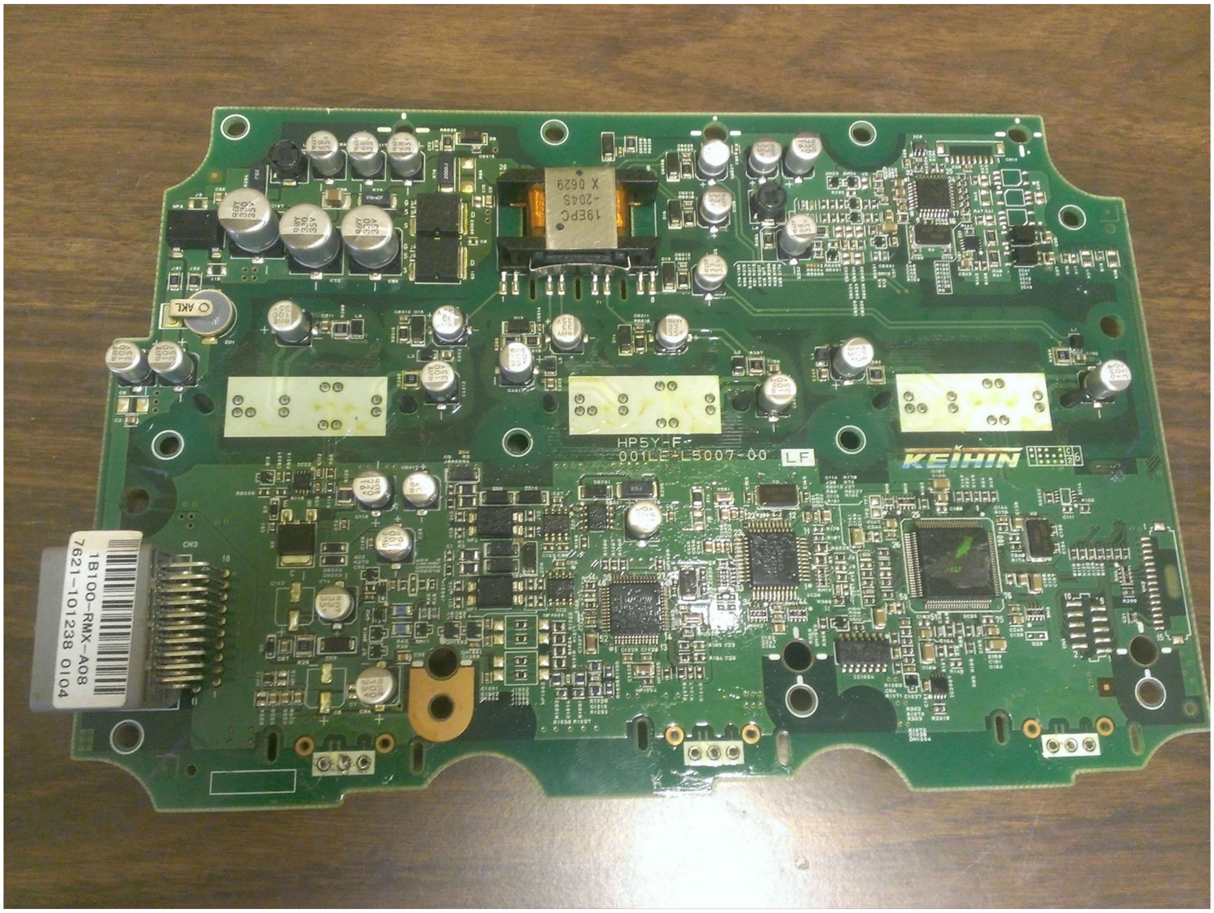


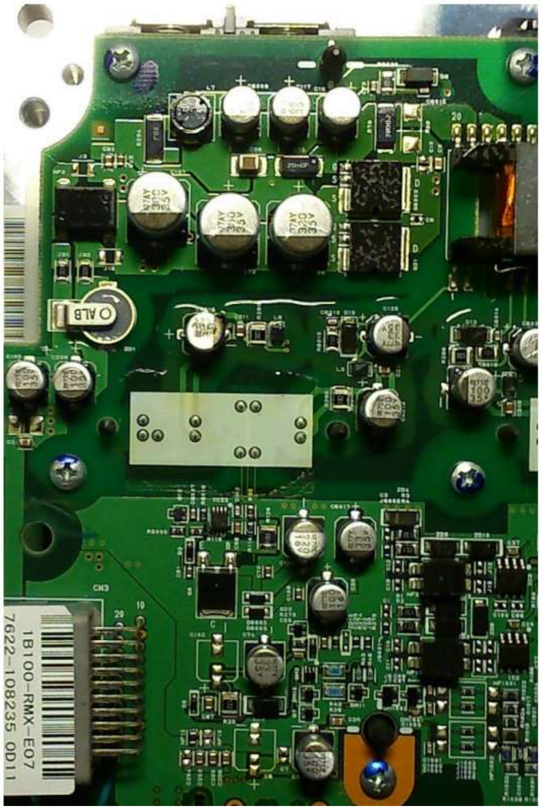

Photo by coleasterling

Connections to the three dual IGBT modules are made in the three white rectangles across the center of the main board. The upper part of the board holds the isolated power supplies for the 6 IGBT gate drives. The lower section contains the main control logic, described below. In this file, the channel numbers for the 3 IGBTs are numbered 1-3 from right to left in the picture above; Channel 1 is furthest from the external connector.

The isolated gate drive power section also includes an 8-bit microcontroller, IC40, a Renesas 7542M2T 8-bit microcontroller. This implies at least one additional 5V logic supply on the power supply side. To the right of the microcontroller is the footprint for an 8-pin connector, CN10. This connector makes available the +5V/RTN logic power supply, as measured back to the Vcc and Gnd pins of the microcontroller. This RTN is connected to the DC Link Negative input to the IGBT’s, and is isolated from the control logic section of the board.

CN10-5: ISO 5V
CN10-6: ISO RTN

**IGBT and driver connections**



In his original reverse-engineering paper, Tomdb identified the connections for each dual IGBT module using the following pin numbering convention:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 6 | 7 | | |
| 1 | | | 4 | | | | | 10 |
| 2 | 3 | | 5 | | | | | 11 |
| | | | | | 8 | 9 | | |

Photo by Tomdb

The pin functions as determined by my testing are:

| Pin | Function | Notes |
|---|---|---|
| 1 | Scaled DC Link Voltage | Referenced to Pin 4. Voltage is ~0.06x actual DC Link voltage. |
| 2 | Heat Sink Temp Sensor (-) | Channel 1 IGBT module only. |
| 3 | Heat Sink Temp Sensor (+) | Channel 1 IGBT module only. |
| 4 | Bottom IGBT Isolated Power (-) | Channel 2 only, connected to ISO RTN via the mainboard |
| 5 | Bottom IGBT Isolated Power (+) | +16.5Vdc to Pin 4 |
| 6 | Bottom Gate | Pulled to Logic Gnd via 10 kΩ. Per Tomdb, works with 3.3V or 5V active high signal. |
| 7 | Logic Gnd | |
| 8 | Top Gate | Pulled to Logic Gnd via 10 kΩ. Per Tomdb, works with 3.3V or 5V active high signal. |
| 9 | IGBT Fault | Pulled to Logic +5V via 2 kΩ. Active low, pulls down to Logic Gnd. |
| 10 | Top IGBT Isolated Power (+) | +16.5V to pin 11 |
| 11 | Top IGBT Isolated Power (-) | |

Current sensor connections are as described by Tomdb, excerpted from his writeup here for completeness:

## Current sensor connection

| | | |
|---|---|---|
| 1 | 2 | 3 |

| Pin | Function |
|---|---|
| 1 | 5 volt |
| 2 | GND directly |
| 3 | 2.48V at 0 amps |

**Gate drive and Fault connections**

Gate drive and fault connections are optically isolated using optocouplers included in the gate drive boards, located underneath the main board. There are three optocouplers shown in the picture below. Note from the picture that two are 5-terminal devices, while the third is a 4-terminal device.

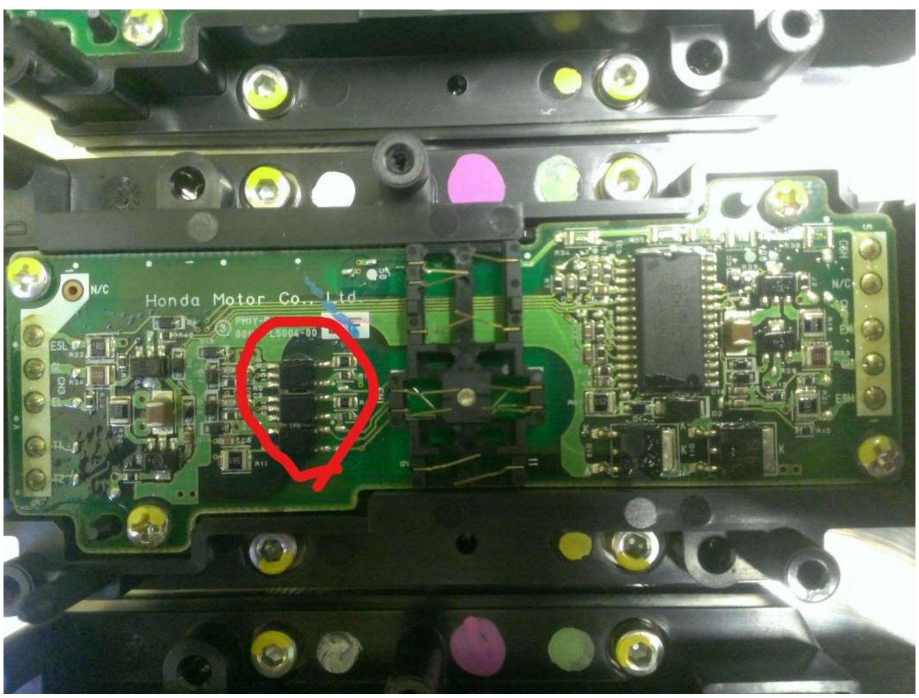
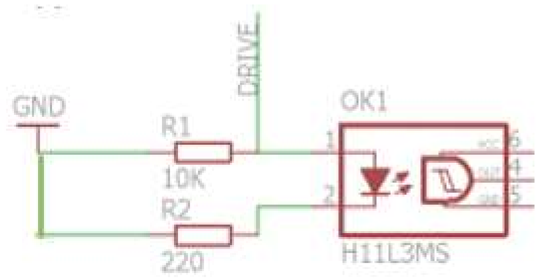



Photo by coleasterling

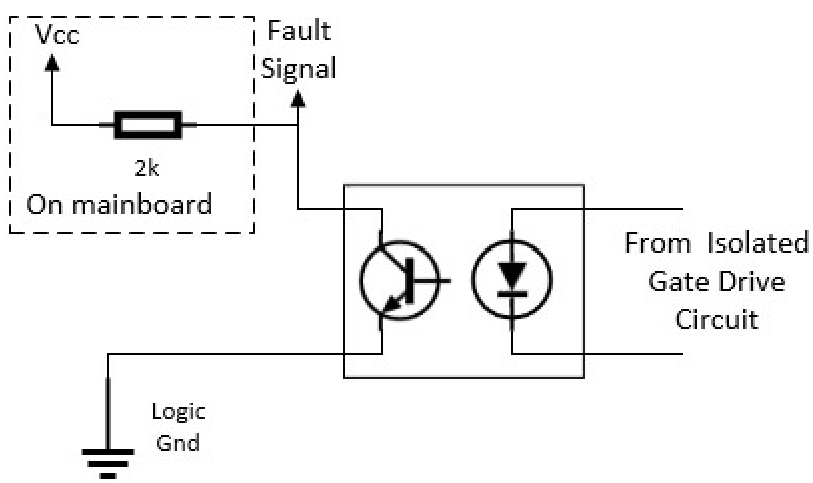
Based on testing, I believe that the two 5-terminal devices pass the top and bottom IGBT "on" commands to the respective gate drives. The third, 4-terminal device, passes a summary fault signal back to the mainboard control logic. The resistor values on the gate drives were determined by Tomdb. , as shown in the figure below adapated from his write-up. There is no resistor for the fault signal device on the gate drive board, and therefor any associated resistors must be located on the main board. The optocoupler circuits are shown below.

Gate Drive (adapted from Tomdb):




The 220Ω resistor limits the current thru the optocoupler diode when the drive signal is applied. The 10kΩ resistor pulls the input down to Logic GND when the drive signal is not active, to prevent spurious IGBT turn-on. Only the Logic GND connection to the mainboard power supplies is required on the gate drive board.

Fault Signal:




The 2kΩ pull-up resistor is sufficient to limit current thru the transistor when turned on, and provides a solid logic high when the transistor is off. This arrangement also avoids the need to connect Logic +5V to the gate drive board, by using the Logic GND already connected for the Gate Drive circuits.

DC Power Connections

Two footprints for connectors are located on the right side of the board. Logic +5V power is available from both connectors

CN1-8: Logic +5V
CN1-9: Logic GND

CN2-15: Logic +5V
CN2-14: Logic GND

In addition, +12V power as supplied thru the main external connector is available from an unpopulated capacitor footprint, C5, located above the connector on the left side of the mainboard. This footprint is located along the circuit path to the input for the isolated power supply.

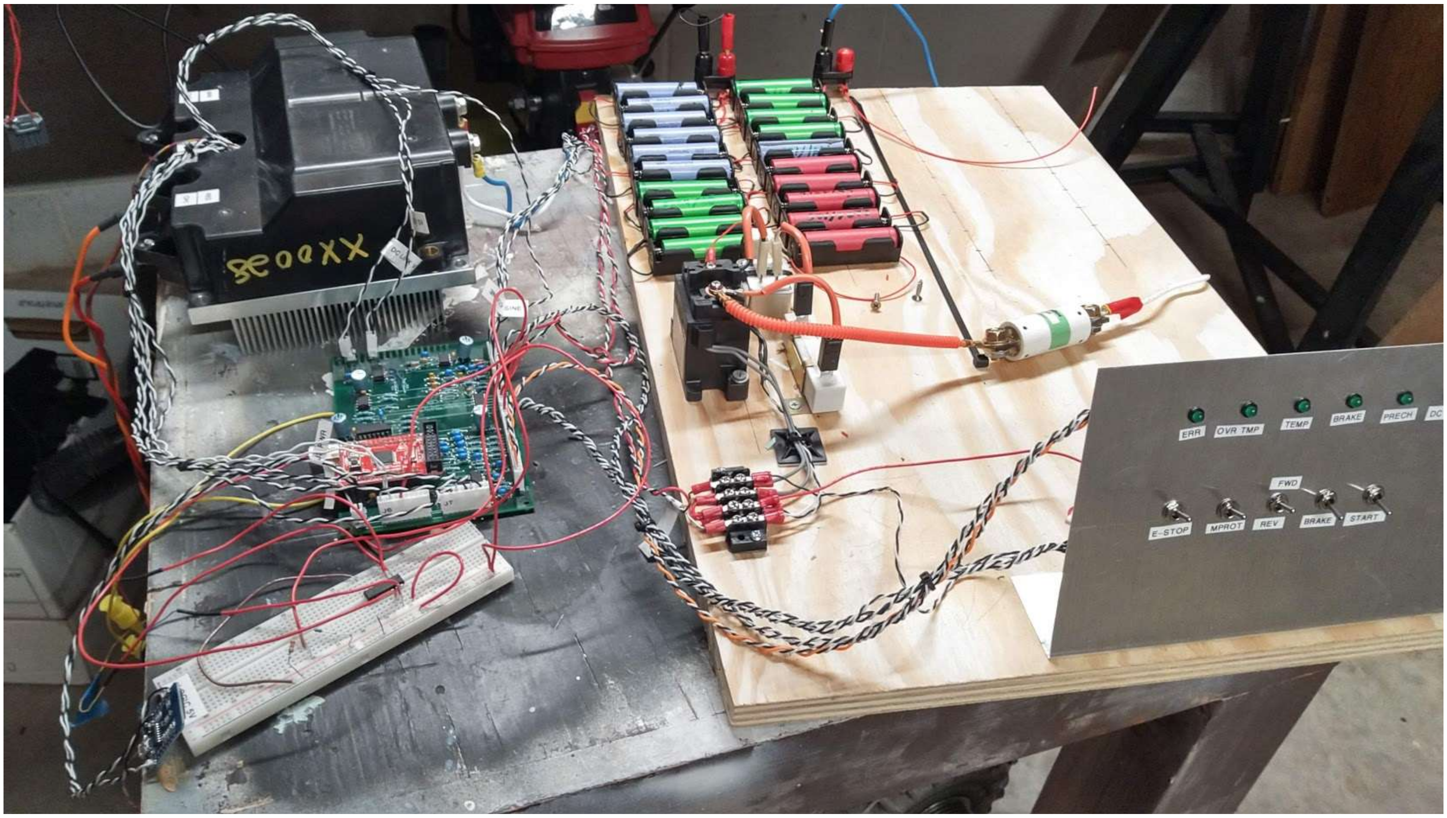
**Testing Comments**

Details of the Huebner controller are available at http://openinverter.org. Testing was performed with a custom board based on the Version 2 mainboard. Software version 4.90R-Sine was used for the final set of testing. A schematic of the custom board is included at the end of this file. +12V power was taken from the C5 footprint, and +5V power from CN1. The custom board used the Olimex H103 board for the processor, which includes a 3.3V power regulator that uses the +5V power as its input. The GM eAssist motor uses a 4-pole resolver as the position sensor, so an exciter circuit was included on the board. No current sensor board was required, and the integral current sensors in the inverter used instead. The custom board originally included a DC/DC converter and scaling network to sense the DC link voltage directly. However, final operation demonstrated that the ISO +5V power from the mainboard could be used to power the isolated side of the sense circuit, and the scaling network was adjusted to use the scaled DC link voltage from pin 1 of Channel 2 IGBT connection. The attached schematic shows this final configuration.

The custom board did not implement any changes to the fault logic to test my hypothesis that pin 9 of each IGBT connection was a fault signal. After operation of the motor was confirmed, the three pin 9 connections were wired to inputs of a 74LS11 triple 3-input AND gate, installed on a separate proto-board, and the output wired to the Desat Fault input (PC7) of the 8-input NAND gate IC3 (see attached schematic). Testing of the faults occurred as a happy accident during testing of the BRAKE input to the controller, which causes the controller to ignore the THROTTLE input and apply a zero torque command, bringing the motor to a quick stop. At lower rpms, the input functioned as expected. However, when spinning the motor at ~3000 rpm, applying the BRAKE input caused an inverter fault, shutting down the PWM control of the IGBTs. The motor coasted down slowly to a stop, and the controller reported a DESAT fault had been received. Based on this, I considered my hypothesis of the pin 9 function to be confirmed. My next version of the controller board will implement this logic.

Operation of the heat sink temperature sensor on Channel 1 was verified using a DMM and heating the sink with a heat gun. However, since the signal is referenced to the ISO GND power, it was not connected to the controller board. The actual temperature sensor used, and its calibration, are unknown.

A picture of the final test setup:

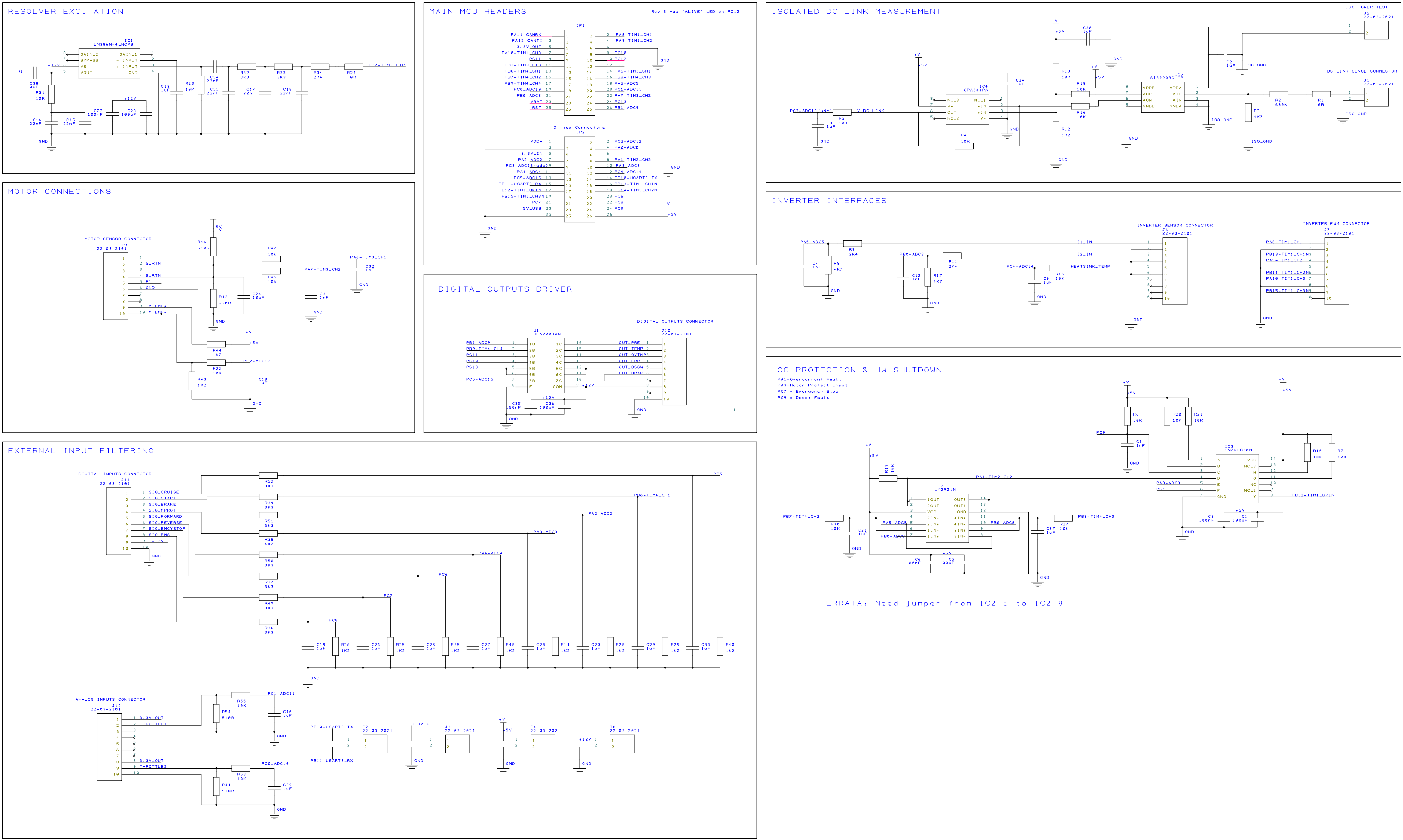



Additional threads of interest may be found here:

https://endless-sphere.com/forums/viewtopic.php?f=30&t=105711

https://endless-sphere.com/forums/viewtopic.php?f=30&t=85514&sid=abb217235db4dac9cf36dfe69a4e8a0e

http://elmoto.net/showthread.php?t=2676



RESOLVER EXCITATION
LM386N-4_NOPB
PD2-TIM3_ETR
MAIN MCU HEADERS
Rev 3 Has 'ALIVE' LED on PC12
JP1
Olimex Connectors
JP2
ISOLATED DC LINK MEASUREMENT
ISO POWER TEST
OPA344PA
SI8920BC-IP
DC LINK SENSE CONNECTOR
PC3-ADC13(udc)
V_DC_LINK
ISO_GND
MOTOR CONNECTIONS
MOTOR SENSOR CONNECTOR
22-03-2101
PA6-TIM3_CH1
PA7-TIM3_CH2
PC2-ADC12
DIGITAL OUTPUTS DRIVER
ULN2003AN
DIGITAL OUTPUTS CONNECTOR
OUT_PRE
OUT_TEMP
OUT_OVTMP
OUT_ERR
OUT_DCSW
OUT_BRAKE
INVERTER INTERFACES
INVERTER SENSOR CONNECTOR
INVERTER PWM CONNECTOR
I1_IN
I2_IN
HEATSINK_TEMP
OC PROTECTION & HW SHUTDOWN
PA1=Overcurrent Fault
PA3=Motor Protect Input
PC7 = Emergency Stop
PC9 = Desat Fault
LM2901N
SN74LS30N
PB12-TIM1_BKIN
ERRATA: Need jumper from IC2-5 to IC2-8
EXTERNAL INPUT FILTERING
DIGITAL INPUTS CONNECTOR
SIG_CRUISE
SIG_START
SIG_BRAKE
SIG_MPROT
SIG_FORWARD
SIG_REVERSE
SIG_EMCYSTOP
SIG_BMS
ANALOG INPUTS CONNECTOR
THROTTLE1
THROTTLE2
PC1-ADC11
PC0_ADC10
PB10-USART3_TX
PB11-USART3_RX