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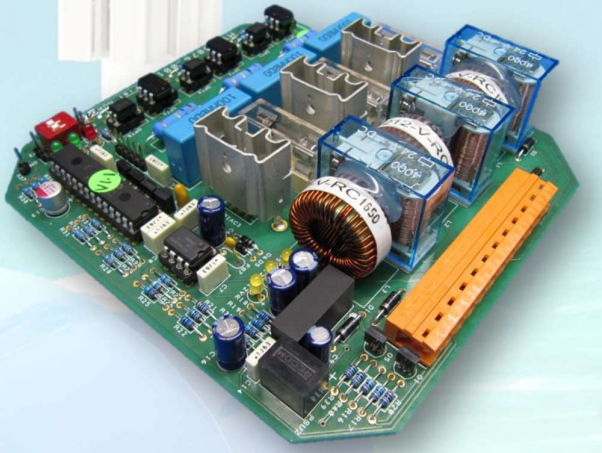
Case Study – 3 Phase Motor Control PCB

Introduction

Our customer approached MTC with an existing thruster control PCB which, due to component obsolescence, along with a lack of manufacturing data, required reverse engineering and design upgrading to produce a reliable and future proof product – backed up by a full manufacturing documentation pack.



Solution

The outline specification was required to match the original product, to allow the new design to act as a drop in replacement. Therefore the new design was matched both mechanically and electrically, however there were areas for obvious improvements in terms of simplifying the design, making it more reliable and less complicated to build and fault find.

MTC engineers replaced areas of the original circuitry with a programmable microcontroller, which allowed many of the previous functionality to be carried out in software. Thus improving reliability, increased functional flexibility, and reduced component count and build complexity.

Specification

24V Supply

The PCB derives its power from a 24VDC supply; this input has a blocking diode, D1, which protects the PCB from accidental supply reversal. The 24V is applied to the DC-DC converter, where +/-12V is generated for use by the analogue input circuitry; these two voltages are indicated with LEDs. The 24V is also applied to another DC-DC converter, which is used to generate 5V for the logic circuitry; this voltage is indicated by another LED. Finally the 24V is applied to the three output relays coils, see below for description of their operation.

Demand Input

The external control voltage applied to the PCB input is typically in the range -5V..+5V. This voltage is buffered, scaled, offset and inverted to give a voltage of approximately 0V..4V at the input to the microcontroller's internal ADC of. The ADC has a 12 bit resolution and has a reference input of 4.096V, this results in a scaling factor of approximately 1mV/bit. i.e. the demand input will be converted to offset binary as follows:

-5V demand = approx. 4095 bits
0V demand = approx. 2048 bits
+5V demand = approx. 0 bits

Motor Drive Outputs

The three phase mains input is applied to the motor via a phase angle controlled triac arrangement. Triac gate trigger pulses are generated, with appropriate timing, by the microcontroller based on input demand voltage. Opto-triacs provide isolation between the high and low voltage side of the circuit. Normally the gate drive from the microcontroller outputs will sit logic low and will go logic high a predetermined delay period after the input phase zero crossing has been detected. The delay period length is determined from the demand input voltage, typically generated by the operator joystick. Snubber networks that prevent false triac triggering. Resistor limit the triac gate current during triggering.

Testing

Following an IPC visual inspection and low voltage power up, the PCBs are subjected to three phase mains voltage testing. This is initially carried out using a simulated test set-up in the lab, followed by a direct connection to an ROV Thruster mounted inside a test tank.