

Motor Control Development Kit

A reference design for low voltage 3-phase AC induction and brushless DC motor control.

Microcontrollers



Never stop thinking.

Motor Control Development Kit

Revision History:2003-06 V 1.0

Previous Version:-

| Page | Subjects (major changes since last revision) |
|------|--|
| 1.0 | June 2003: First Release |
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| | |

References

Infineon C868 User's Manual

http://www.infineon.com/cmc_upload/documents/048/247/UM_c868_BA_singlepage_v1.0.pdf

Infineon TLE6280GP Datasheet

http://www.infineon.com/cmc_upload/documents/014/220/TLE6280GP_P6_1.pdf

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1 Introduction

This user manual describes the MCDK, Motor Control Development Kit reference design board and its functions.

The MCDK reference design provides a turnkey solution for driving 3-phase low voltage brushless DC and AC induction motors, which are usually powered by batteries. The hardware design applies a broad range of Infineon IC products including microcontroller, bridge driver, power transistor, temperature sensor and voltage regulator. Infineon also makes Hall Effect sensors which often are placed inside Brushless DC motors for position sensing. Also included in the kit is reference software. This reference solution allows engineers to shorten the development cycle, reduce the design cost and cut the time from concept to market significantly.

The reference software provided with the MCDK release demonstrates a variable speed drive for a high speed brushless DC motor with hall sensors, the motor has the following features:

- 24V DC Supply
- 3-phase, 4-pole, trapezoidal
- $\frac{3}{4}$ Horse Power
- Speed up to 30,000 RPM

The software can be trivially changed to adopt different type of 3-phase brushless DC motors.

2 MCDK Overview

2.1 Parameters

The MCDK reference design meets the following specifications:

Low Voltage: 12V ~ 24V DC

High Current: 50A, continuous DC

Output Power: Up to 1.2KW

Power Efficiency: > 95%

2.2 Features

- 8-bit MCU: C868 with on-chip 8kB SRAM, 5 channel 8-bit ADC and powerful PWM module CAPCOM6E
- 3-Phase Bridge Driver: TLE6280G
- 6 OptiMOS MOSFETs: SPB80N06S2-05, TO263 package, 55V / 80A / 4.8 mΩ $R_{DS(on)}$
- EEPROM: 8kB to store program + stand alone boot option
- RS232: Interface to PC for SW development + boot from PC option
- Protection: shut down protection for over current and over temperature
- Board can be used for current/torque or speed control
- Supports Hall-Effect sensors or sensor-less control
- Extension for alternative MCU like XC164
- Small foot print: 5¼" x 3" dimension (133.4mm x 76.2mm)
- SW development tools: Keil Compiler + Debugger or Mini Debugger
<http://www.keil.com> + free reference software

2.3 Assembly

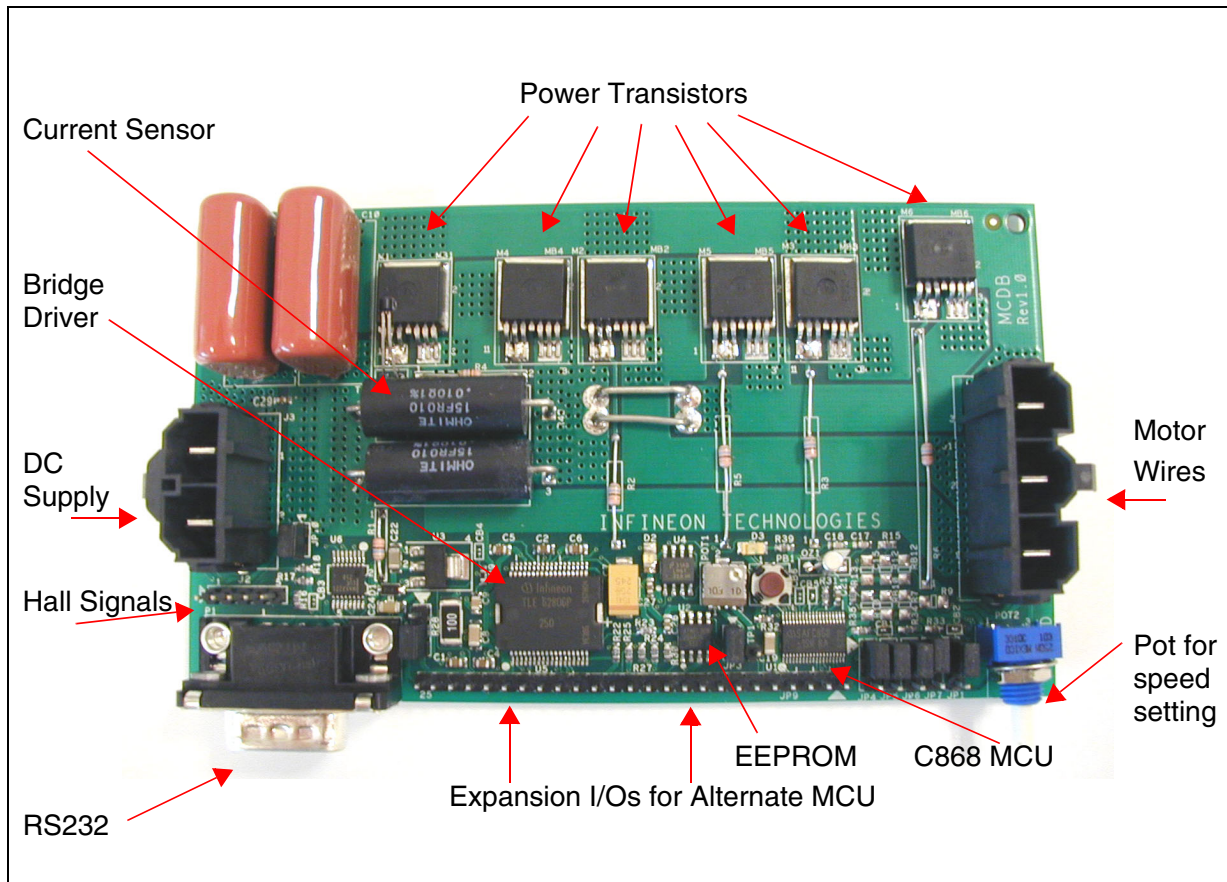


Figure 1 Assembly of the MCDK Board

3 Hardware Design

The hardware is designed with maximum versatility and flexibility to meet fluctuating motor drive needs:

- CPU selections between C868 and alternatives like C164, XC164 and TriCore.
- Power Transistor Packages compatible in both DPAK and D2PAK
- Bridge Driver selection between TLE6280 or TLE6287
- Motor rotor position detection through hall sensors or sensor-less calculation.
- Booting sequences via EEPROM, RS232 or on-chip ROM.
- Circuit protections for over current and over temperature conditions

The following block diagram illustrates the basic idea to drive a 3-phase AC induction or BLDC motor.

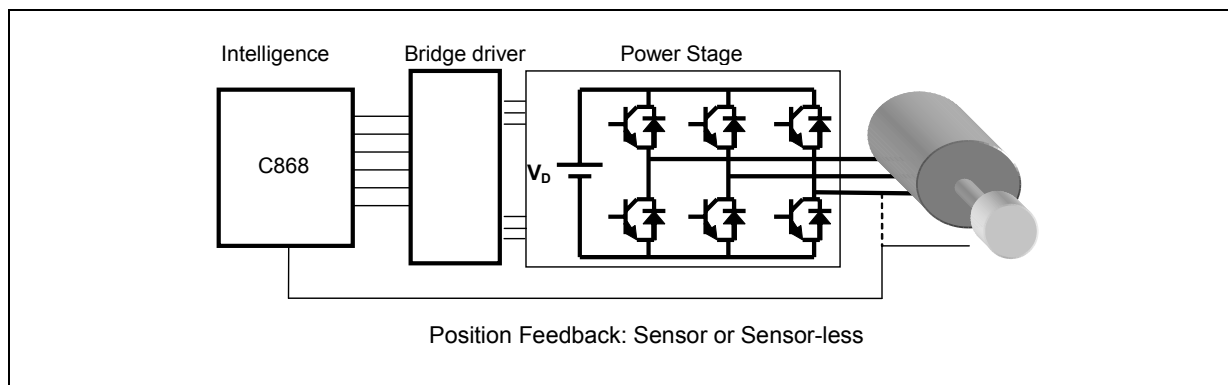


Figure 2 Block Diagram of 3-phase Motor Control Circuit

The Infineon C868 microcontroller implements a powerful PWM unit CAPCOM6E, which is able to generate optimized PWM waveform for all kind of motor controls with minimal CPU load.

The following diagram illustrates how the CAPCOM6E can generate 6-channels of PWM signals according to the 3 hall sensor position signals, to drive a 3-phase BLDC motor. The CAPCOM6E is very flexible and can generate practically any pattern that is desired.

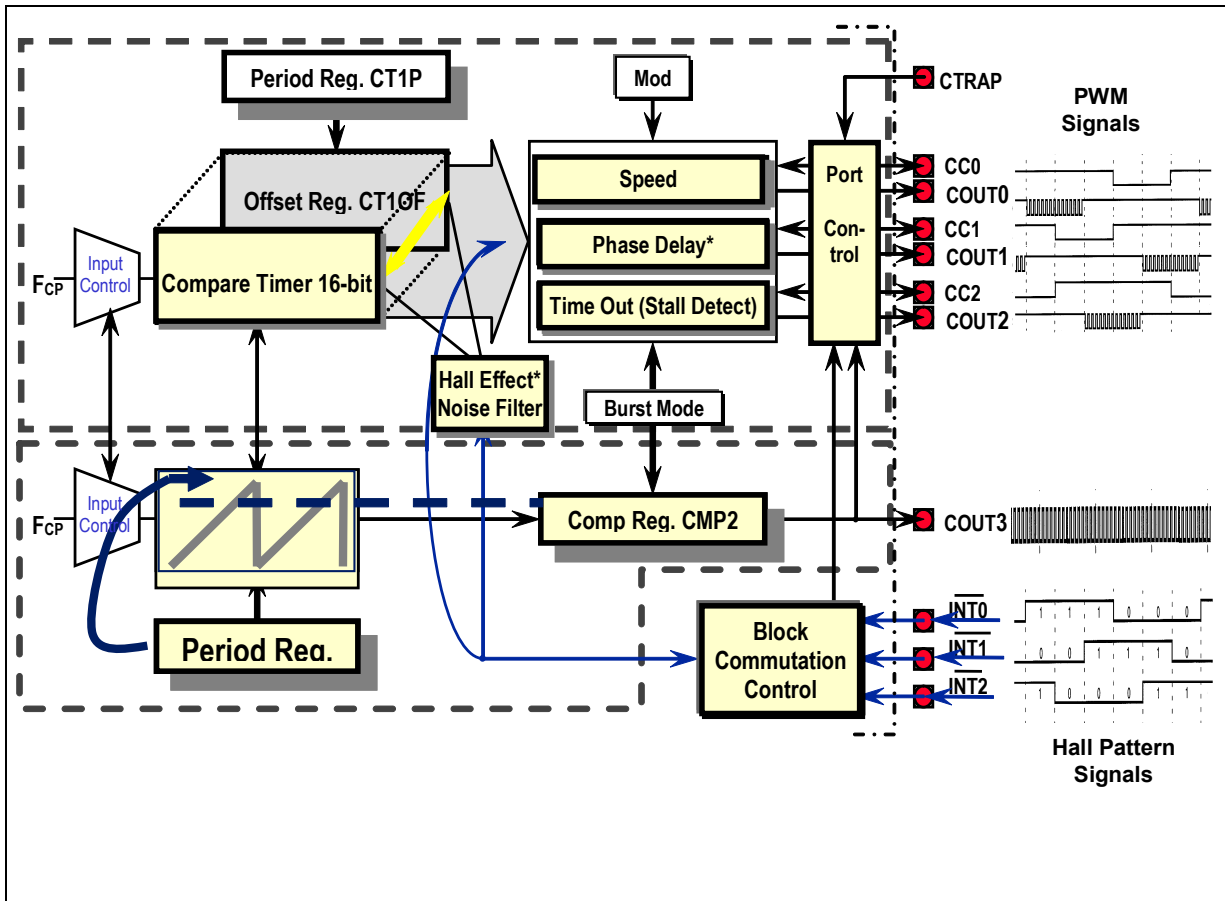


Figure 3 Block Diagram of the CAPCOM6E PWM Unit (with C868)

4 Board Configurations

The MCDK board is pre-configured during production. The following table shows the factory setting for circuit breaks and jumpers:

- CB1: Close
- CB2: Close
- CB3: Open
- CB4: Open
- CB5: Close
- CB6: Open
- JP1: 1+2
- JP2: 2+3
- JP3: Close
- JP4: 1+2
- JP5: 1+2
- JP6: 1+2
- JP7: 1+2

4.1 Circuit Break Settings

The circuit breaks are pre-set in the assembly process, a solder drop between the gap makes the circuit break ‘Close’, otherwise the circuit break is ‘Open’.

The circuit breaks CB4, CB5 and CB6 are used to select two types of Infineon bridge drivers, the factory setting is choosing the TLE6280. To choose the TLE6287, the configuration for CB4, CB5 and CB6 will be:

Table 1 Configurations for using TLE6287 bridge driver

| | CB4 | CB5 | CB6 |
|---------|-------|------|-------|
| TLE6287 | Close | Open | Close |

The circuit breaks CB1 and CB2 make the board flexible for users who want to use the A/D ports of the microcontroller for alternate purpose. In this case, they need to be ‘Open’. While CB3 is closed, the board can supply a DC voltage to the external RS232 connections where opto-isolation can be applied.

4.2 Jumper Settings

Jumper setting is more flexible, users can change “on-the-fly” to meet specific applications.

Table 2 Jumper setting for bootstrap mode

| JP1: Bootstrap Mode Selection | |
|--------------------------------------|------------------|
| 1 - 2 | Bootstrap Mode |
| 2 - 3 | Normal ModeTable |

Table 3 Jumper setting for logic power supply voltage

| JP2: Logical Power Supply Voltage Selection | |
|--|--------------------------|
| 1 – 2 | V _{CC} = + 5V |
| 2 – 3 | V _{CC} = + 3.3V |

Table 4 Jumper setting for boot enable and disable

| JP3: Boot Enable/Disable | |
|---------------------------------|------------------------|
| Open | Boot from PC via RS232 |
| Close | Boot from EEPROM |

Table 5 Jumper setting for position detection methods

| JP4, JP5 and JP6: Position Detection | |
|---|-------------|
| 1 - 2 | Hall Sensor |
| 2 - 3 | Sensor-less |

Table 6 Jumper setting for A2D input selection

| JP7: A/D Input selection | |
|---------------------------------|-------------------|
| 1 - 2 | Temperature Input |
| 2 - 3 | Current Input |

5 Get Started

5.1 Run the Demo

The EEPROM on the board has been pre-programmed with a BLDC motor control reference demo, the microcontroller C868 will boot from the EEPROM and automatically fetch then execute the code after power-up. The potentiometer for speed setting is preset at zero RPM.

To run the demo, follow these steps:

- Hook up the motor wires and hall sensor signals of the brushless DC motor to the board.
- Connect a 12~24V battery with at least 1A output current to the board, the board is powered up then.
- Turn on the knob of the potentiometer, the motor will starts to spin.

Since the reference code is designed for a demo motor, the code has to be fine tuned for the right type of motor applied.

5.2 Re-program the EEPROM

Users can re-program the EEPROM with their own code, to do this, follow these steps:

- Switch off the power supply by disconnecting the battery.
- Open the jumper JP3.
- Connect a RS232 cable to the host PC, and execute the Loader program on the PC.
- Connect the battery back so the board will be powered up again.
- Close the jumper JP3.
- Download your code into the EEPROM.

6 Utilize an Alternative Microcontroller

The expansion I/O connector, JP9, allows users to apply an alternative microcontroller to drive the motor, for example, the Infineon C166 series microcontrollers with integrated CAPCOM6(E) PWM units such as the XC164.

The signals of the expansion I/O JP9 are described in the following table:

Table 7 Description of Expansion I/Os of JP9

| Pin # | Name | Description |
|-------|------------------|--|
| 1 | CC0 | First phase high side PWM signal |
| 2 | COU0 | First phase low side PWM signal |
| 3 | CC1 | Second phase high side PWM signal |
| 4 | COU1 | Second phase low side PWM signal |
| 5 | CC2 | Third phase high side PWM signal |
| 6 | COU2 | Third phase low side PWM signal |
| 7 | CTRAP | Over current trap signal |
| 8 | POS0 | Rotor position signal |
| 9 | POS1 | Rotor position signal |
| 10 | POS2 | Rotor position signal |
| 11 | Temp/ Current | Temperature or Current amplitude |
| 12 | SPEED | Motor speed setting |
| 13 | MFP | Multifunction control signal for bridge drive |
| 14 | ERR | Error signal from bridge drive |
| 15 | TX | Transmitting signal of RS232 |
| 16 | RX | Receiving signal of RS232 |
| 17 | CS | Chip select signal for EEPROM |
| 18 | SIO | Serial I/O pin of EEPROM |
| 19 | SCK | Serial Clock signal of EEPROM |
| 20 | GND | Ground |
| 21 | RST | Reset signal for CPU |
| 22 | +3.3V | Logic voltage supply when C868 used |
| 23 | +5V | Logic voltage supply when alternate MCU used, i.e., C164xx |
| 24 | GND | Ground |
| 25 | +24V_IN | DC power supply (filtered) |

Utilize an Alternative Microcontroller

The expansion I/Os provide all the necessary signals for external microcontroller to access the EEPROM, RS232 interface and motor drive circuits. There are two ways to utilize an alternate microcontroller: One is to design a mezzanine board that can plug on top of the MCDK board through the JP9 connector, the other way is to connect a 25pin flat cable to an existing microcontroller board (e.g., a starter kit). For the MCDK board, some changes have to be done: the on-board C868 device must be un-populated to avoid signal conflicts, also the jumper JP2 should be re-positioned if the alternate microcontroller uses a different I/O logic voltage supply, i.e., +5V.

7 Appendix 1: Layout

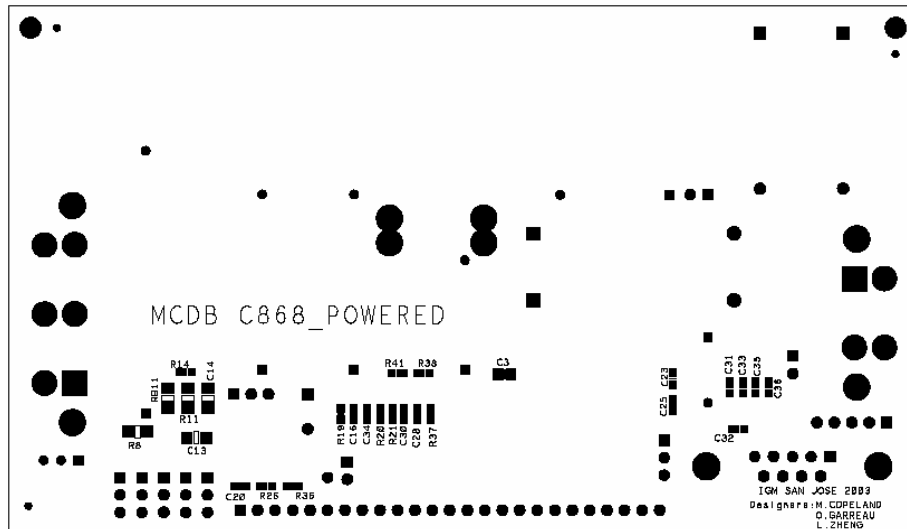


Figure 4 Assembly Bottom

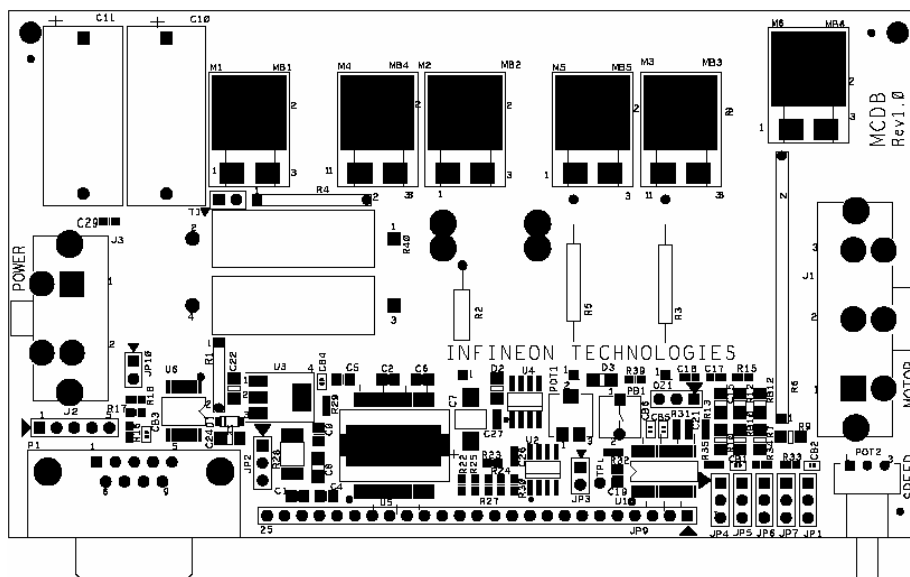


Figure 5 Assembly Top

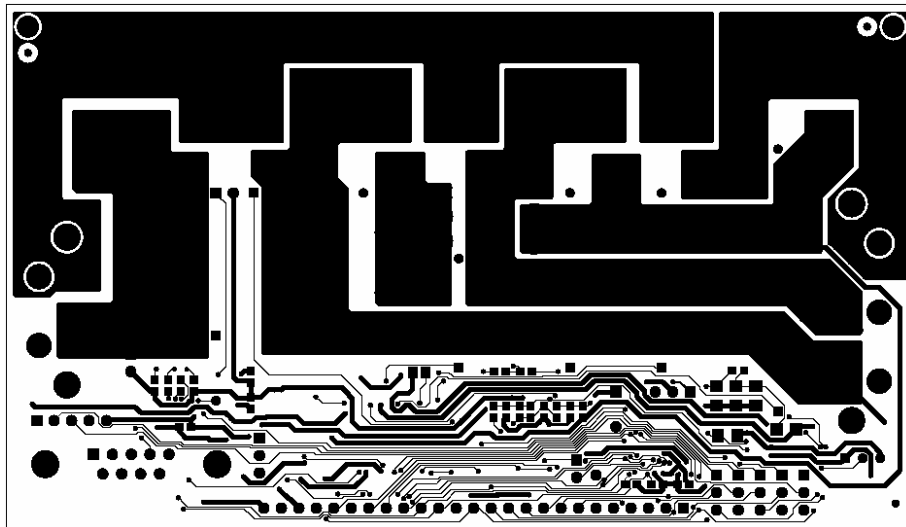


Figure 6 Bottom

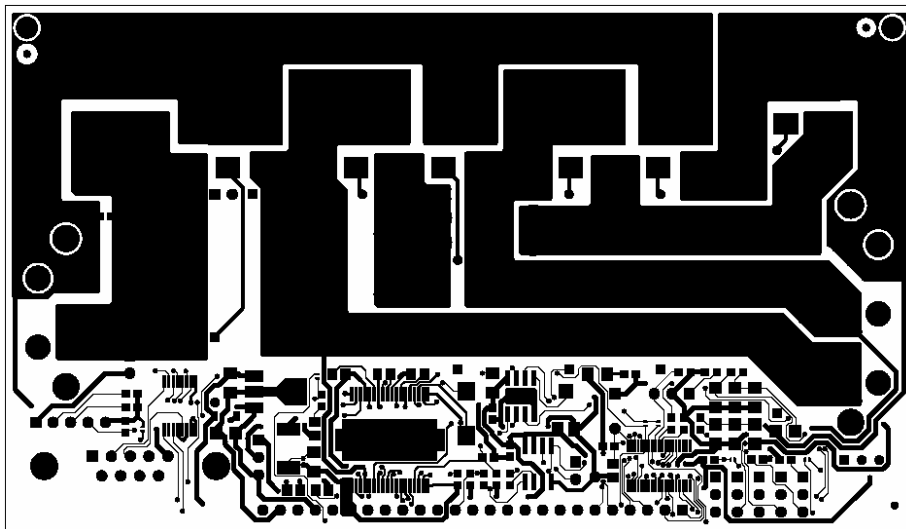


Figure 7 Top

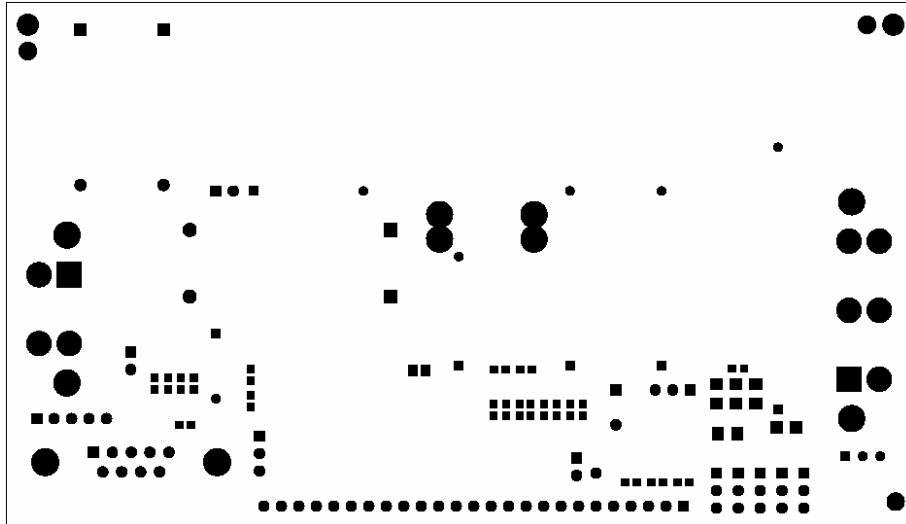


Figure 8 Mask bottom

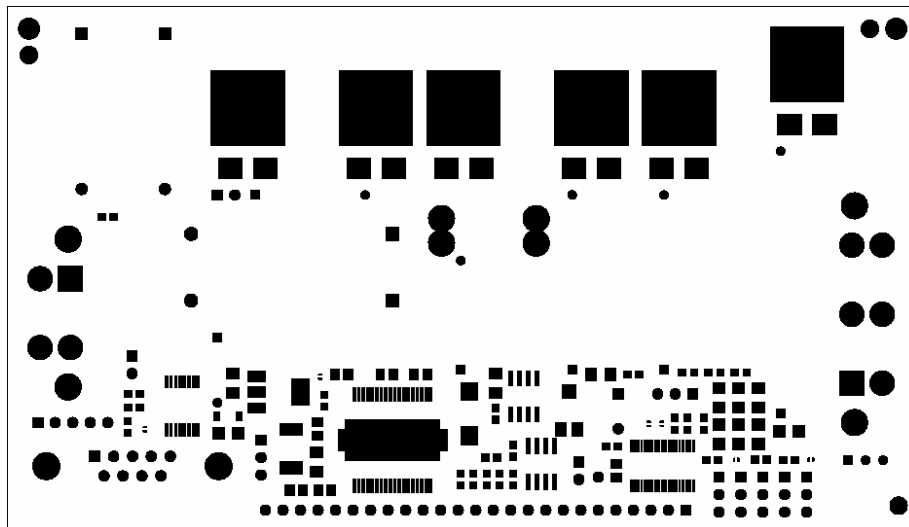


Figure 9 Mask top

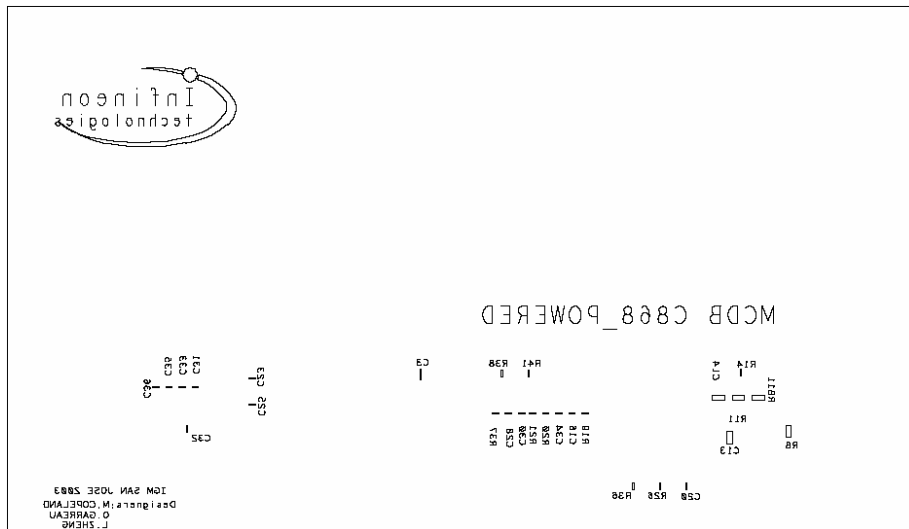


Figure 10 Silk Bottom

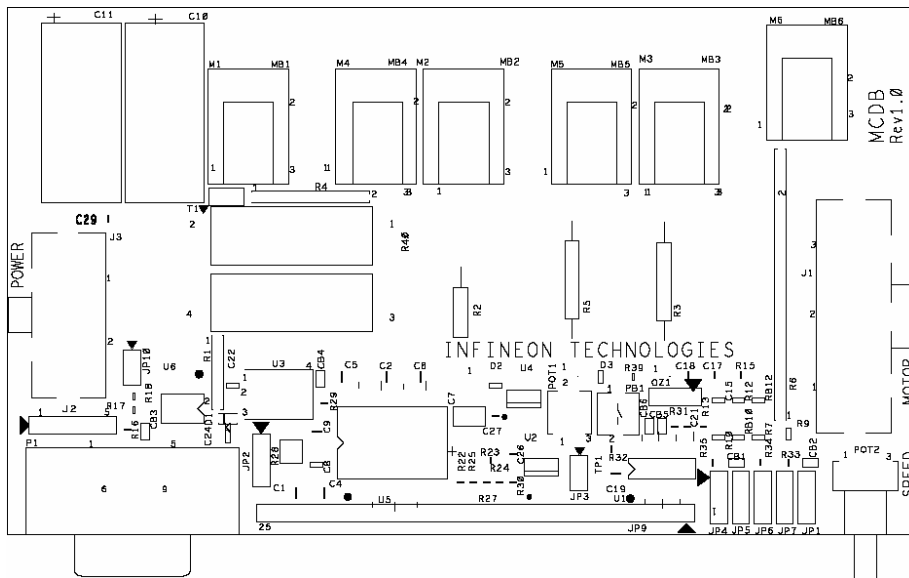


Figure 11 Silk Top

8 Appendix 2: BOM

Table 8 Bill of Material for MCDK Reference Design

| Designator | Quantity | Part Type | Footprint |
|--|----------|---------------------------------|--------------------------------|
| CB1->CB6 | 6 | Solder drop | custom footprint |
| C1->C3 | 3 | 2.2F | _0805 |
| C4->C6 | 3 | 0.22 μ F | _0805 |
| C7 | 1 | 15uF / 25V | D-PACK |
| C8, C19 | 2 | 1 μ F | _1206 |
| C9 | 1 | 12nF | _0805 |
| C10, C11 | 2 | 10 μ F-100v | Radial/Bulk |
| C16 | 1 | 10nF | _0603 |
| C17, C18 | 2 | 22pF | _0603 |
| C20, C21, C23, C25, C26, C27, C29, C31, C32, C33, C35, C36 | 12 | 100nF | _0603 |
| C22, C24 | 2 | 10 μ F | _1206 |
| C28 | 1 | 10nF | _0603 |
| D1 | 1 | 1N4148 | SOD-123 |
| D2 | 1 | 1201:red/ orang, 1202:red | _1206 |
| D3 | 1 | 404-1059-1- ND | _1206 |
| JP1,JP2,JP4->JP7 | 6 | HEADER 3 | SIL3 |
| JP3 | 1 | JUMPER | SIL2 |
| JP9 | 1 | HEADER 25 | SIL25 |
| JP10 | 1 | HEADER 2 | SIL2 |
| J1 | 1 | Motor Wires | Conn Hdr Vert Mini Fit SR 3Pos |
| J2 | 1 | Hall Sensor Signals | SIL5 |
| J3 | 1 | DC Power Supply | Conn Hdr Vert Mini Fit SR 2Pos |

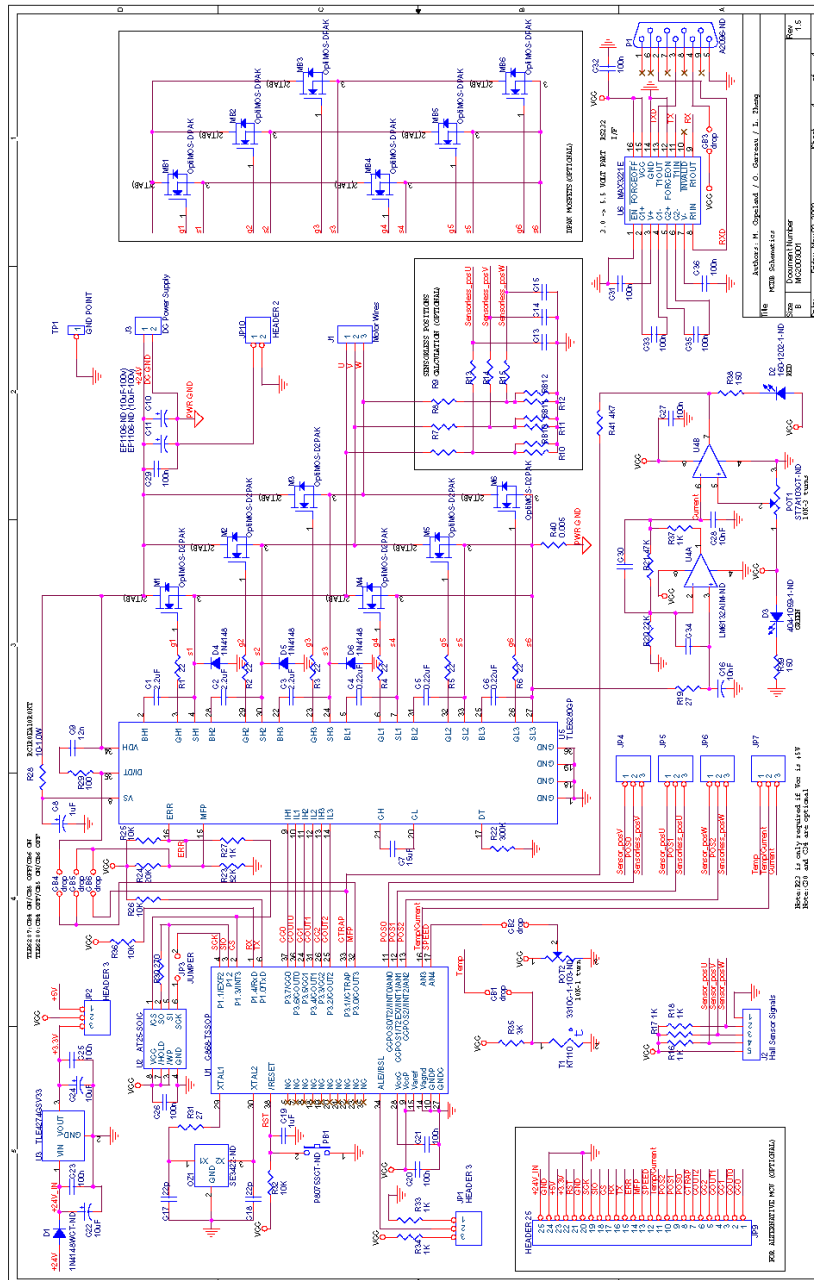
Table 8 Bill of Material for MCDK Reference Design

| Designator | Quantity | Part Type | Footprint |
|-------------------------|----------|------------------------|---|
| M1->M6 | 6 | SPB80N06 S2-05 | P- TO263 -7-3 |
| OZ1 | 1 | CSTLA10M 6T55002-B0 | SIL3 |
| PB1 | 1 | P8075SCT- ND | SPST |
| POT1 | 1 | ST7A103CT -ND | 7mm Squared SMD J-Lead-CT |
| POT2 | 1 | 3310C-1- 103-ND | 9mm Squared RT ANGLE PLAS |
| P1 - MALE | 1 | A2096-ND | DB9-PCB |
| R1->R6 | 6 | 22Ω | Axial 1/4W type ERDS2T |
| R13->R18, R27, R33, R34 | 9 | 1KΩ | _0603 |
| R19, R31 | 2 | 27Ω | _0603 |
| R20 | 1 | 22KΩ | _0603 |
| R21 | 1 | 47KΩ | _0603 |
| R22 | 1 | 300KΩ | _0603 |
| R24 | 1 | 20KΩ | _0603 |
| R25, R26, R32, R36 | 4 | 10KΩ | _0603 |
| R28 | 1 | 10Ω-1.0W | _2512 |
| R29 | 1 | 100Ω | _0603 |
| R30 | 1 | 270Ω | _0603 |
| R35 | 1 | 3KΩ | _0603 |
| R37 | 1 | 1KΩ | _0603 |
| R38, R39 | 2 | 150Ω | _0603 |
| R40 | 2 | 0.005Ω | resistors in parallel, 0.010 ohms@5W |
| R41 | 1 | 4K7Ω | _0603 |
| TP1 | 1 | GND POINT | SIL1 |
| T1 | 1 | KT110 | SIL2 |
| U1 | 1 | C868- TSSOP | tssop38 |

Table 8 Bill of Material for MCDK Reference Design

| Designator | Quantity | Part Type | Footprint |
|------------|----------|--------------------|--------------|
| U2 | 1 | EEPROM 64K 2.7V | SOIC8 |
| U3 | 1 | TLE4274GS V33 | P-SOT223-4-1 |
| U4 | 1 | LM6132AIM -ND | SOIC8 |
| U5 | 1 | TLE6280GP | P-DSO36-12 |
| U6 | 1 | MAX3221E | TSSOP16 |

9 Appendix 3: Schematics



10 Appendix 4: Waveforms

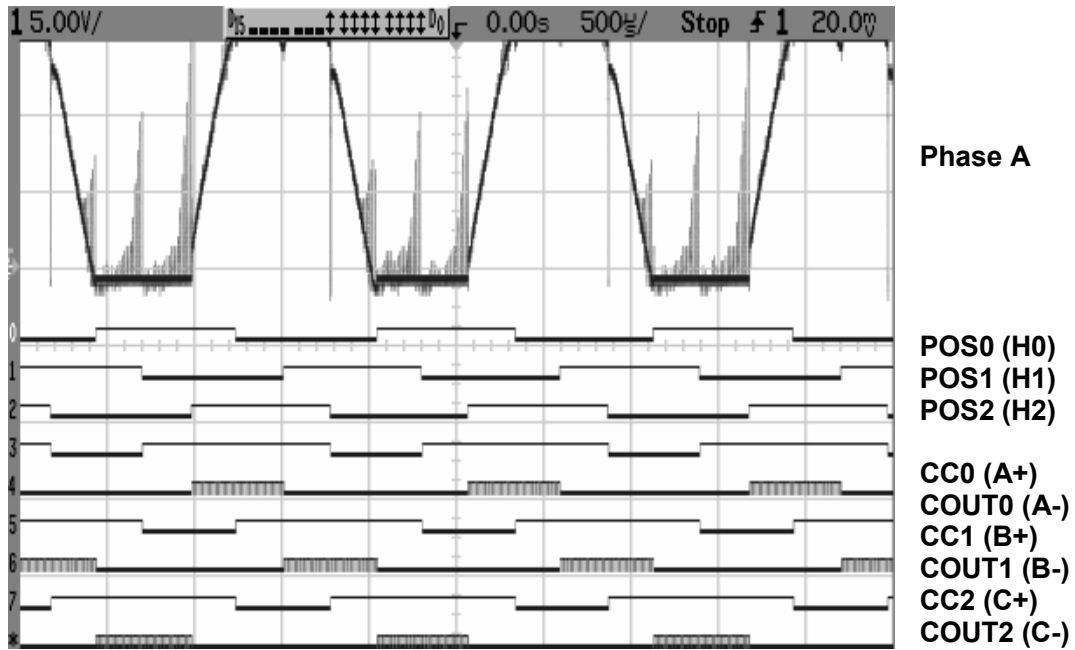


Figure 12 Waveforms of PWM and Hall Pattern Signals Driving a 3-phase BLDC motor (Measured with a Mixed Signal Oscilloscope).

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