

# Motor Control Development Kit

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

Microcontrollers



Never stop thinking.

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## Motor Control Development Kit

### Revision History:2003-06 V 1.0

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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](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](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
- ¾ 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 m $\Omega$   $R_{DS(on)}$
- 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

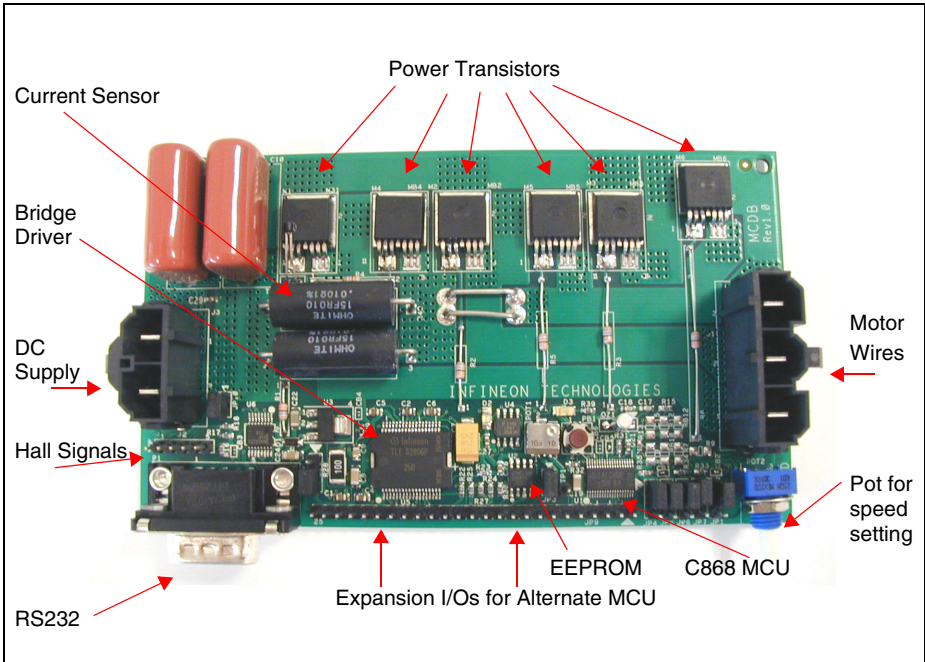


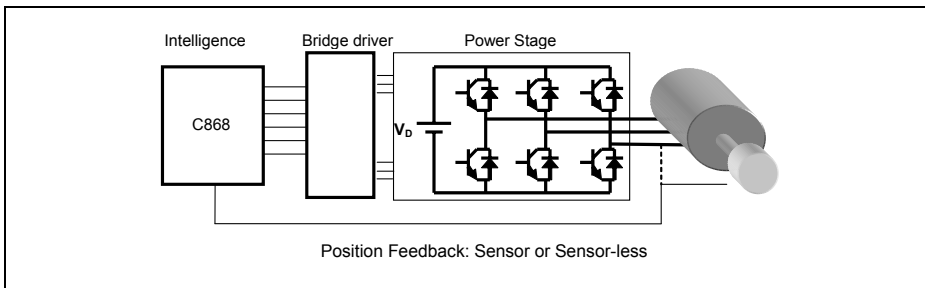
Figure 1 Assembly of the MCDK Board

### 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.

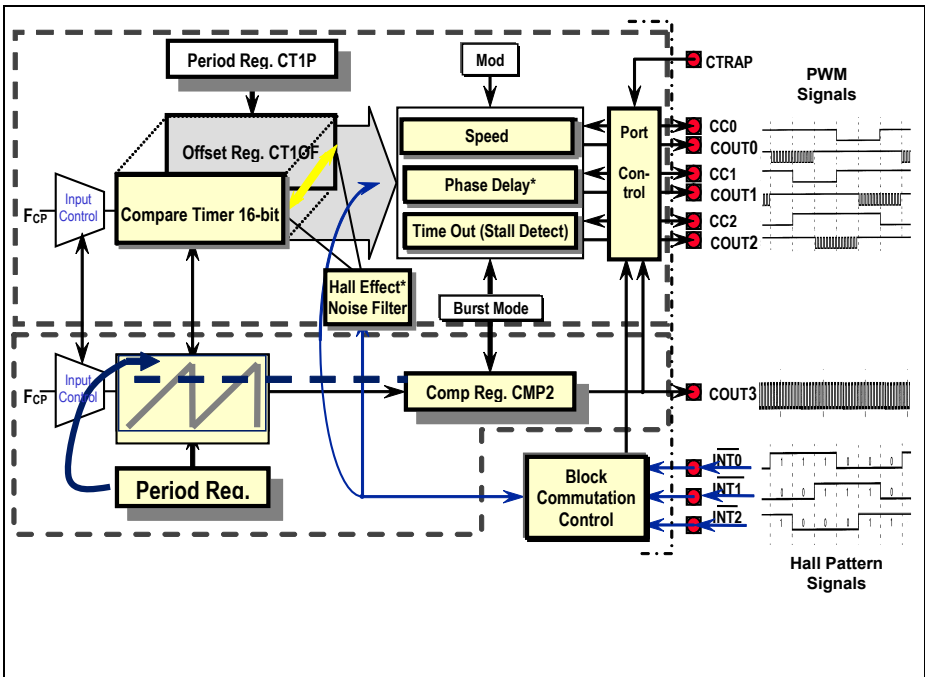


Figure 3 Block Diagram of the CAPCOM6E PWM Unit (with C868)

## 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**

<b>JP1: Bootstrap Mode Selection</b>	
1 - 2	Bootstrap Mode
2 - 3	Normal ModeTable

**Table 3 Jumper setting for logic power supply voltage**

<b>JP2: Logical Power Supply Voltage Selection</b>	
1 – 2	V <sub>cc</sub> = + 5V
2 – 3	V <sub>cc</sub> = + 3.3V

**Table 4 Jumper setting for boot enable and disable**

<b>JP3: Boot Enable/Disable</b>	
Open	Boot from PC via RS232
Close	Boot from EEPROM

**Table 5 Jumper setting for position detection methods**

<b>JP4, JP5 and JP6: Position Detection</b>	
1 - 2	Hall Sensor
2 - 3	Sensor-less

**Table 6 Jumper setting for A2D input selection**

<b>JP7: A/D Input selection</b>	
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

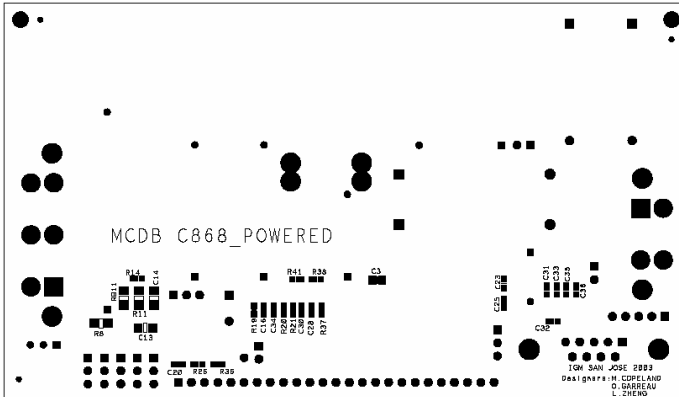


Figure 4 Assembly Bottom

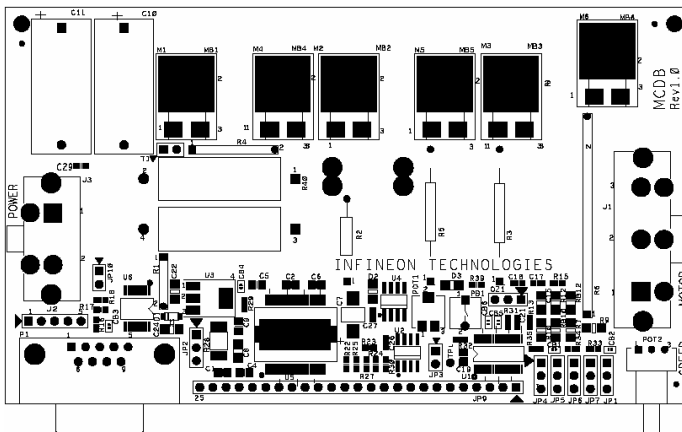


Figure 5 Assembly Top

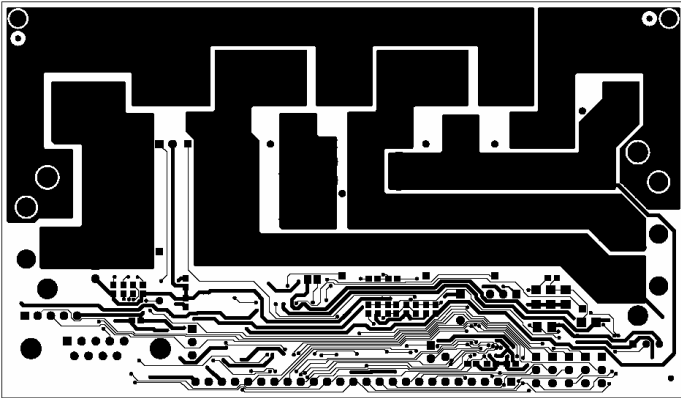


Figure 6 Bottom

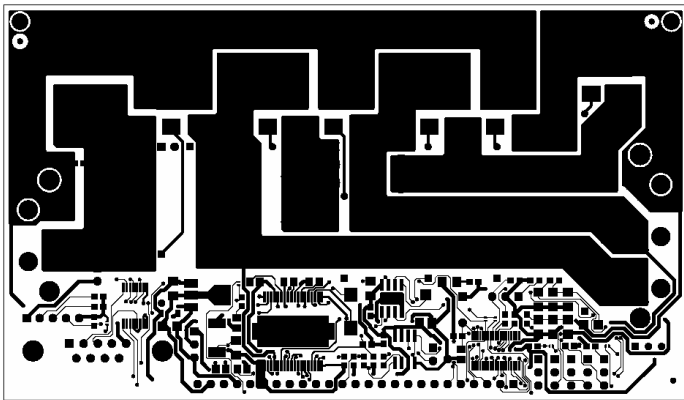


Figure 7 Top

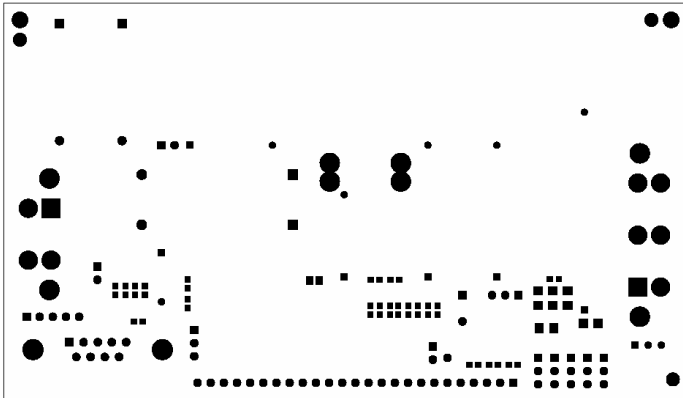


Figure 8 Mask bottom

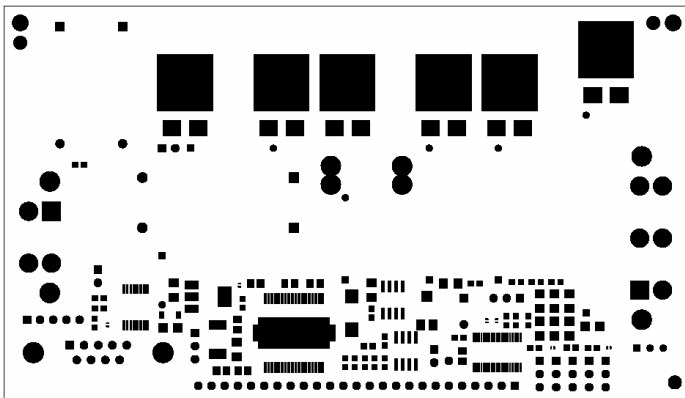


Figure 9 Mask top

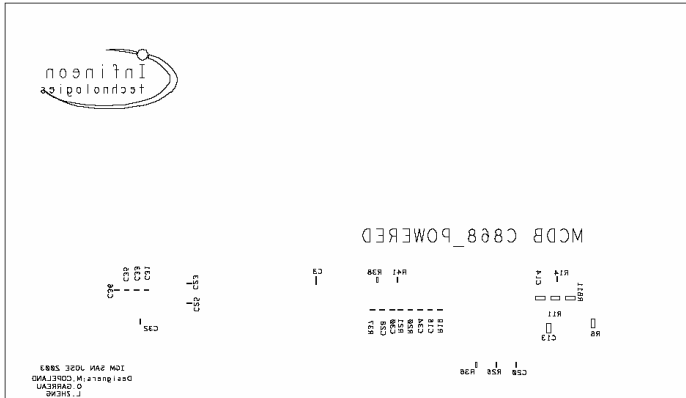


Figure 10 Silk Bottom

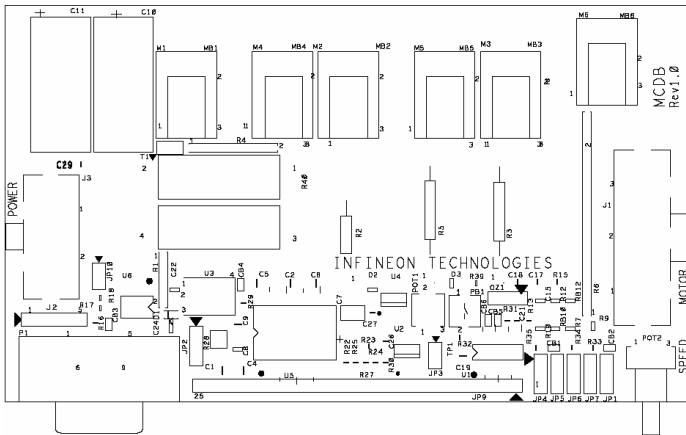


Figure 11 Silk Top



## 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 $\mu$ F	_0805
C7	1	15uF / 25V	D-PACK
C8, C19	2	1 $\mu$ F	_1206
C9	1	12nF	_0805
C10, C11	2	10 $\mu$ 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 $\mu$ 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

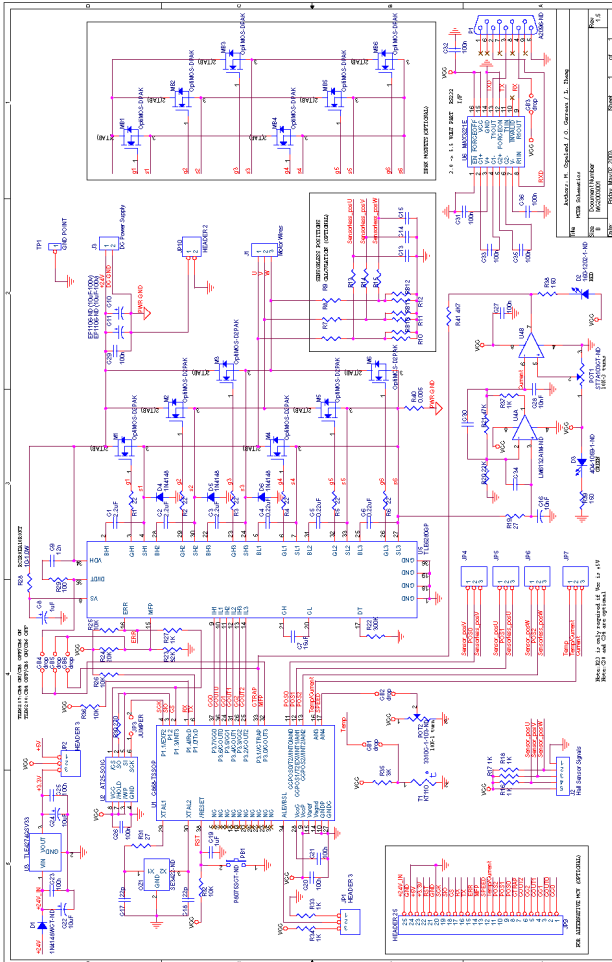
**Table 8 Bill of Material for MCDK Reference Design**

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	22 $\Omega$	Axial 1/4W type ERDS2T
R13->R18, R27, R33, R34	9	1K $\Omega$	_0603
R19, R31	2	27 $\Omega$	_0603
R20	1	22K $\Omega$	_0603
R21	1	47K $\Omega$	_0603
R22	1	300K $\Omega$	_0603
R24	1	20K $\Omega$	_0603
R25, R26, R32, R36	4	10K $\Omega$	_0603
R28	1	10 $\Omega$ -1.0W	_2512
R29	1	100 $\Omega$	_0603
R30	1	270 $\Omega$	_0603
R35	1	3K $\Omega$	_0603
R37	1	1K $\Omega$	_0603
R38, R39	2	150 $\Omega$	_0603
R40	2	0.005 $\Omega$	resistors in parallel, 0.010 ohms@5W
R41	1	4K7 $\Omega$	_0603
TP1	1	GND POINT	SIL1
T1	1	KT110	SIL2
U1	1	C868- TSSOP	tssop38

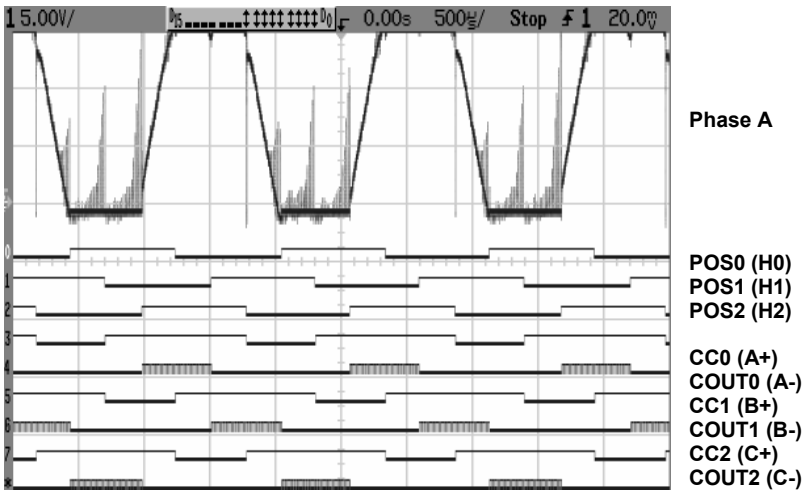
**Table 8 Bill of Material for MCDK Reference Design**

<b>Designator</b>	<b>Quantity</b>	<b>Part Type</b>	<b>Footprint</b>
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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