TI Designs
DesignDRIVE Development Kit – A Reference Design for Servo and AC Inverter Drives

Design Overview

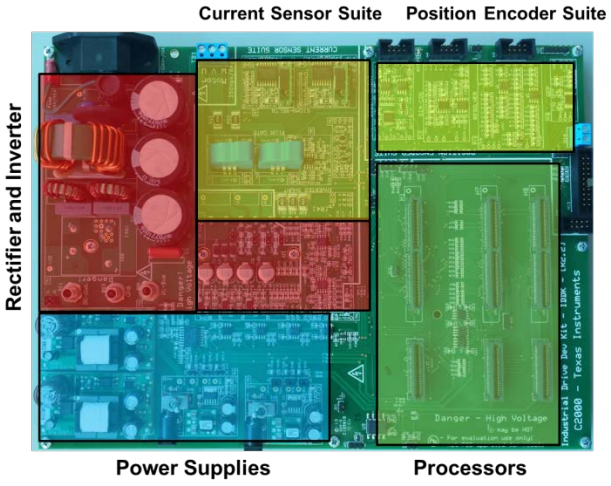
The DesignDRIVE Development Kit is a reference design for a complete industrial drive directly connecting to a three phase ACI or PMSM motor. Many drive topologies can be created from the combined control, power and communications technologies included on this single platform. Includes multiple position sensor interfaces, diverse current sensing techniques, hot-side partitioning options and expansion for safety and industrial Ethernet.

The *ONE* place to create *MANY* designs for Industrial Drives…

Design Resources

TIDM-SERVODRIVE	Design Folder
DesignDRIVE Solutions	Tool Folder
DesignDRIVE Development Kit - IDDK	Tool Folder
TMS320F28377D Ind-Drive SOC	Product Folder
Delfino™ C2000™ Real-time MCUs	Product Folder
Isolated Measurement for Motor Drives	Tools Folder

Block Diagram



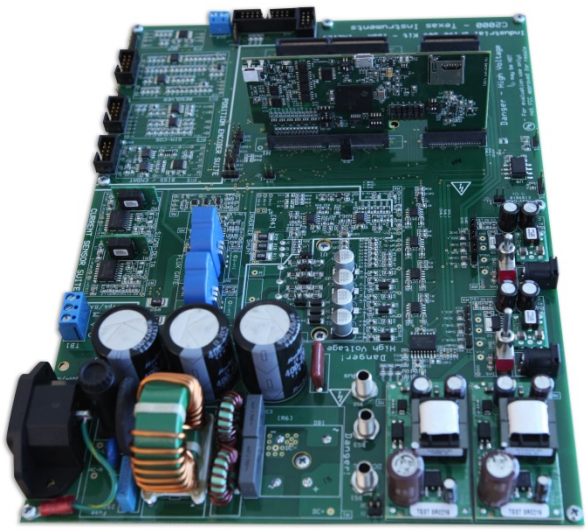
Design Features

- Multiple current sensing topologies
- Configurable isolation partitioning
- High performance real time control
- Multi-protocol encoder interfaces
- Flexible real time connectivity
- Functional safety expansion port

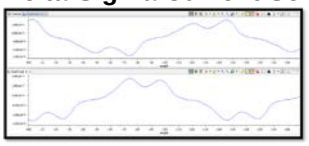
Featured Applications

- Industrial AC Drives
- Industrial Servo Drives
- Industrial Robotics
- Computer Numerically Controlled Machining
- Elevators

Board Image



Delta-Sigma Current Sensing Results



1 Key System Specifications

Functional Block	Macro Reference	Macro Function
Power Supplies	M2	Isolated DC-DC converter – 400 V to 15 V
	M3	DC-Power Supply – Linear Reg 15 V – 5 V to 3.3 V
	M8	Isolated DC/DC Converter – 400 V to 15 V
	M9	DC-Power Supply – Linear Reg 15 V – 5 V to 3.3 V
Rectifier and Inverter	M1	AC Main Power Entry
	M4	3-Phase Inverter
Current Sensor Suite	M5	Flux Gate – Motor Current Sense Interface
	M6	Overcurrent Protection
	M7	Sigma-Delta – Motor Current Sense Interface
Position Encoder Suite	M10	QEP Interface
	M11	Resolver Interface
	M12	EnDat Encoder Interface
	M13	Sin-Cos Encoder Interface
Processors	Main board	All other functions

Figure 1: Hardware Macros in the IDDK and Their Functions

2 System Description

The DesignDRIVE kit (IDDK) is a single platform that facilitates development and evaluation of design solutions for many industrial drive and servo topologies. The IDDK offers support for a wide variety of motor types, sensing technologies, encoder standards, and communications networks. The IDDK also offers easy expansion to develop with real-time Ethernet communications and functional safety topologies that enable more comprehensive, integrated system solutions. Based on the real-time control architecture of TI's C2000™ microcontrollers (MCUs), the kit is ideal for the development of industrial inverter and servo drives used in robotics, computer numerical control (CNC) machinery, elevators, materials conveyance, and other industrial manufacturing applications.

The IDDK offers an integrated-drive design with a full-power stage to drive a 3-phase motor, easing evaluation of a diverse range of feedback sensing and control topologies. The kit includes a 180-pin HSEC controlCARD based on the TMS320F28377D C2000 Delfino™ MCU, which integrates dual C28x real-time processing cores and dual CLA real-time coprocessors that provide 800 MIPS of floating-point performance with integrated trigonometric and FFT acceleration.

The sophisticated sensing peripherals on the TMS320F28377D MCU include sigma-delta filter modules with up to eight input channels, four high-performance 16-bit ADCs, and eight windowed comparators. These peripherals enable the IDDK to support shunt, flux gate/HALL, and sigma-delta current sensing simultaneously. For position feedback, the IDDK leverages integrated MCU support for the resolver and incremental encoder interfaces. In addition, customers can also explore configuration options that place the MCU on either side of the high-voltage isolation barrier.

The board is designed to plug into 110-V/220-V AC mains, deliver up to 8 amps, and to drive motors up to 1 horsepower.

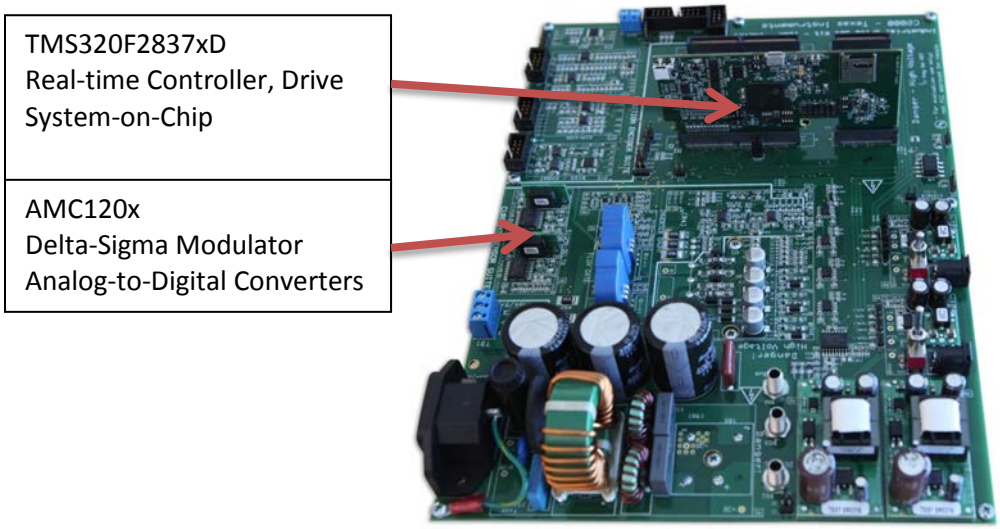


Figure 2 DesignDRIVE IDDK Reference Design

2.1 TMS320F2837x C2000™ Delfino™ Microcontrollers

The 32-bit Delfino™ series of C2000 Real-time Control microcontrollers brings leading floating-point performance and analog integration to real-time control applications. The Delfino series of microcontrollers simplifies development and delivers high performance for demanding real-time applications. The Delfino series features the new dual-core microcontroller running at 200 MHz on each CPU and also has single-core options running up to 300 MHz.

With a high-performance core, control-optimized peripherals, integrated analog and scalable development platform, the Delfino series of microcontrollers can reduce system cost, increase system reliability and boost performance for applications such as industrial power electronics, power delivery, renewable energy and smart sensing.

Key Features	Key Benefits
• Dual-core C28x at 200 MHz each • Floating Point Unit • Trigonometric math unit (TMU) • Viterbi Complex Unit (VCU) • Two programmable 32-bit floating-point real-time accelerators (CLAs) on chip • Up to 1 MB of Flash • Dual DMA controllers • High Resolution PWMs (down to 55ps) • Four 16 bit ADCs, 1 MSPS • 32-bit QEP and Capture modules • Programmable PWM Trip	• Leading 32-bit performance for real-time control applications • Reduced system cost through integrated high performance analog • Improved application performance and efficiency

2.2 AMC1204DW – Delta-Sigma Modulators

- Galvanically isolated current sensing solution
- 16-bit output at 78.1 kSPS
- ±10 A at <0.3% (uncalibrated accuracy)
- 78dB SNR (min)

3 Block Diagram

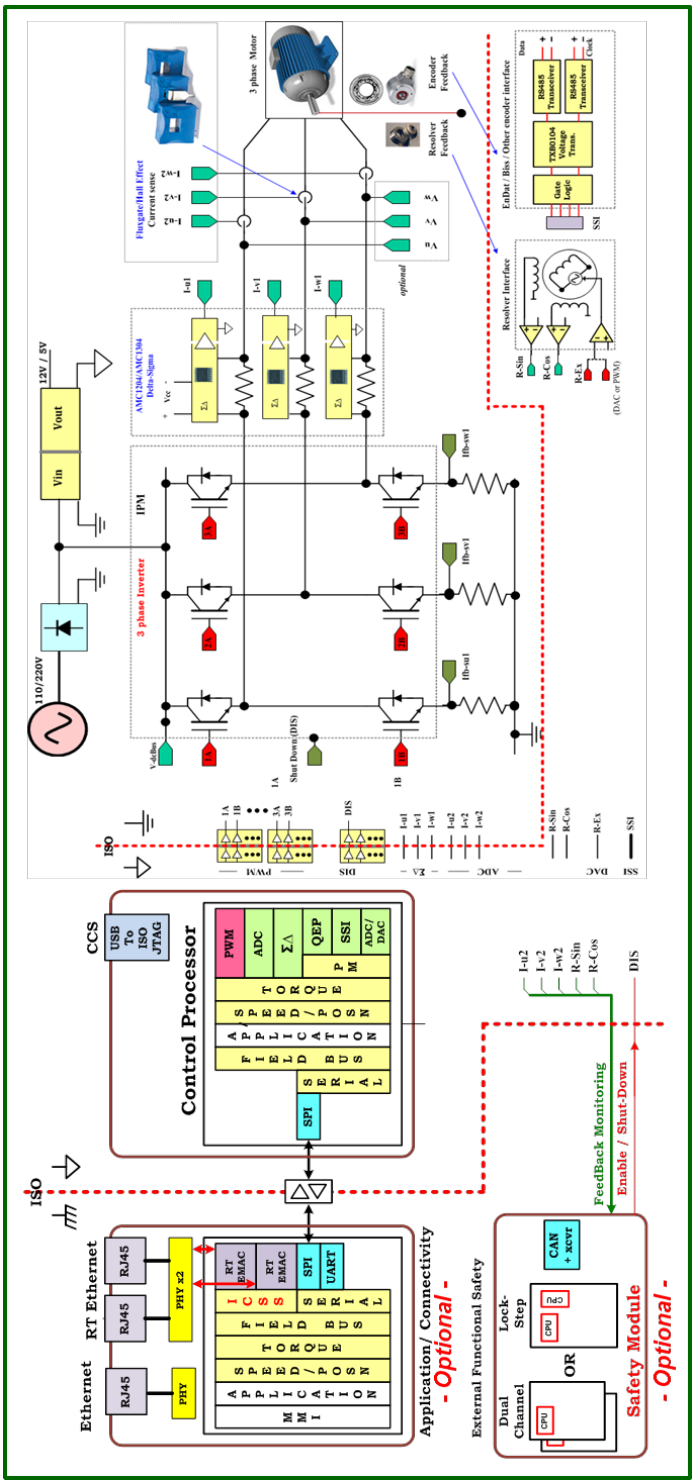


Figure 3 A Block Diagram of TIDM-SERVODRIVE, TMDXIDDK377D

4 System Design Theory

This design has a low-voltage domain represented by the controller and a high-voltage domain represented by the rectifier and the inverter domain. Please refer to the following documentation for more details:

- DesignDRIVE Development Kit IDDK v2.2 - User's Guide
- DesignDRIVE Development Kit IDDK v2.2 - Hardware Reference Guide

5 Getting Started Hardware

As the default configuration, the experiment uses one common HOT GND that connects the control and power circuits. (See entry 4 of Table 3-2, *Power Supply Connection Configuration* in the *DesignDRIVEDevelopment Kit IDDK v2.2 Hardware Reference Guide* [SPRUI23].)

For setting up the experimental hardware, perform the following steps:

1. Ensure that jumpers [Main]-J6, [Main]-J7, and [Main]-J8 in front of macro M9, are populated.
2. Ensure that resistors [Main] R8 through R13 are populated.
3. Ensure that GND plane resistors R14 and R15 are mounted. (See Figure 3-12,*Various GND Planes onthe Bottom Side of Board* and Figure 3-13, *Default Connection of Various GND Planes* of *DesignDRIVE Development Kit IDDK v2.2 Hardware Reference Guide* [SPRUI23].)
4. Unpack the TMDXCNCD28377D control card.
5. Slide the card into the connector slot of [Main]-H1. (Push down using even pressure on both ends of the card until it cannot slide further. To remove the card, spread open the retaining clips and pull the card out, applying even force at the edges.)
6. Connect a USB cable to connector J1 on the control card. (The control card isolates the JTAG signals between the C2000 device and the computer. LED D2 on the control card should light.)
7. Ensure that toggle switch [M9]-SW1 is in the Int position.
8. Connect an isolated 15-V DC-power supply to [M9]-JP1.
9. Turn on toggle switch [M9]-SW1. ([M9]-LD1 should turn on.

NOTE: More LEDs on the control card light up. These LEDs indicate that the control card is receiving power from the board. Connect the motor to the [Main]-TB1 terminals only after finishing the first incremental build

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10. Apply the DC-bus power only when the guide instructs.

Two options exist to get DC-bus power:

- To use an external, variable DC-power supply, do the following:
  - (a) Set the power-supply output to zero.
  - (b) Connect [Main]-BS2 and [Main]-BS3 to the + and – terminals of the DC-power supply, respectively.
- To use AC-Mains power, do the following:
  - (a) Connect [Main]-BS1 to [Main]-BS2 using a banana plug cord.
  - (b) Connect the end of the AC-power cord to [Main]-P1.
  - (c) Set the output of the variac to zero.
  - (d) Connect the variac to the wall supply through an isolator.
  - (e) Connect the other end fo the AC-power cord to the output of the variac.

6 Getting Started Firmware - Installing Code Composer and controlSUITE

1. If not already installed, install Code Composer v6.x or later from http://www.ti.com/tool/CCSTUDIO
2. Go to http://www.ti.com/controlsuite
3. Run the controlSUITE installer.

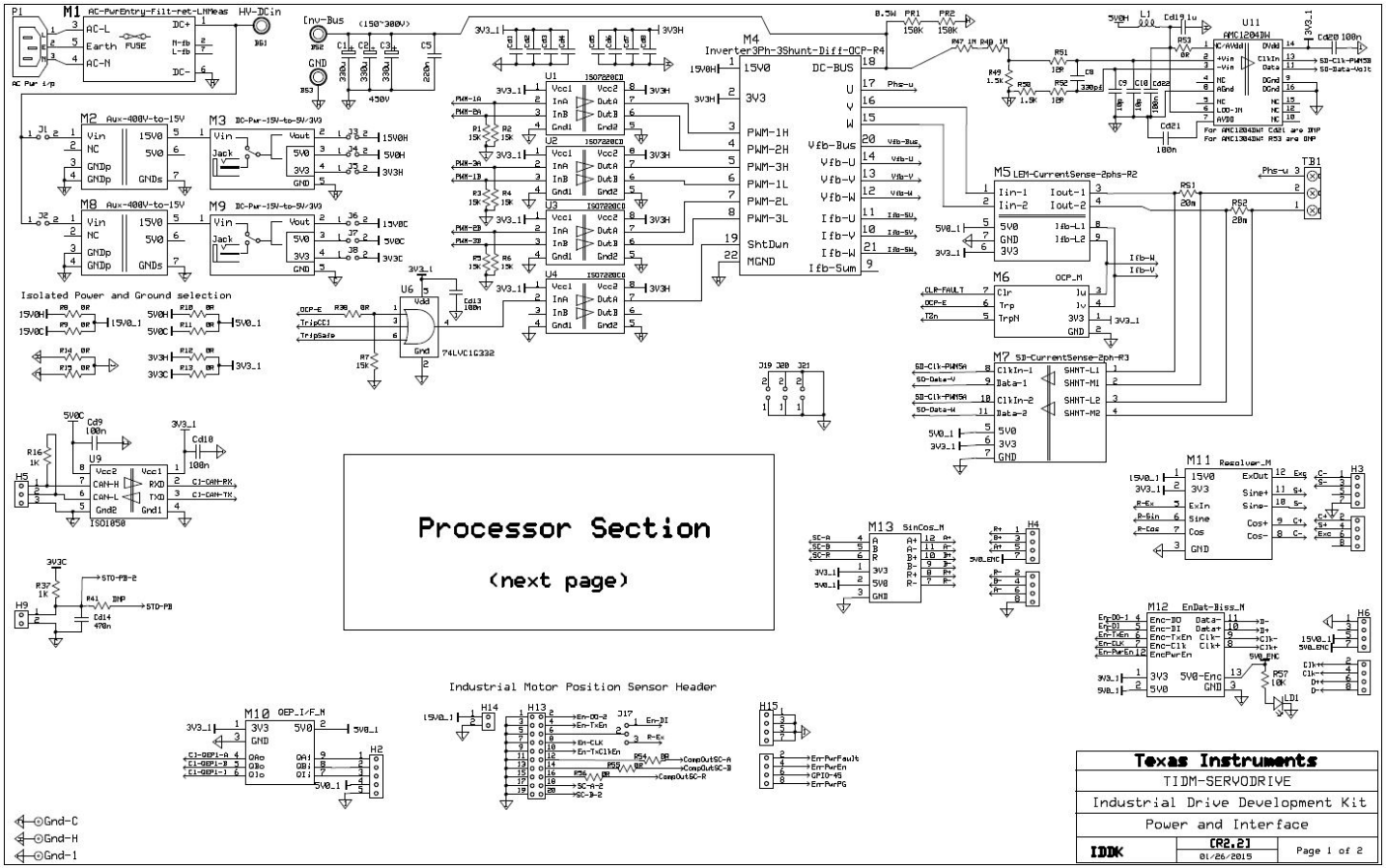
NOTE: Allow the installer to download and update any automatically-checked software for C2000.

Please see DesignDRIVE Development Kit IDDK v2.2 - User's Guide for complete instructions for setting up the project.

7 Design Files

7.1 Schematics

To download the Schematics for each board, see the design files at http://www.ti.com/tool/TIDM-SERVODRIVE.



7.2 Bill of Materials

To download the Bill of Materials for each board, see the design files at http://www.ti.com/tool/TIDM-SERVODRIVE

Item	# needed per macro	Reference		Part Description and Value		Manufacturer Part Number	Digikey Part #
1	6	[Main]-U1,U2,U3,U4, U5, U8		Digital Isolator, Quad 4/0, 25Mbps, ISO7220CD		ISO7220CD	296-26075-5-ND
2	1	[Main]-U7		Digital Isolator, Quad 4/0, 25Mbps, ISO7221ADR		ISO7221ADR	296-21955-2-ND
3	1	[Main]-U6		IC 3-INPUT OR GATE SOT-23-6, SN74LVC1G332		SN74LVC1G332	296-18587-1-ND
4	1	[Main]-U9		ISO1050 - IC TXRX CAN 5V 8SOP		ISO1050	296-24818-1-ND
5	1	[Main]-U11		AMC1204DW, SOIC16 - Isolated SDM		AMC1204DW	296-28557-ND
6	3	[Main]-C1,C2,C3		Electrolytic Capacitors - Leaded 400V, 220uF 25X30 20%			1189-2025-ND
7	1	[Main]-C5		Metal Poly Cap. 0.22uF, 400V DC, Lead spacing 0.591" (15.00mm) - EF4224			EF4224-ND
8	19	[Main]-Cd1,Cd2,Cd3,Cd4,Cd5,Cd6,Cd7,Cd8, Cd9,Cd10,Cd11, Cd12, Cd13, Cd15, Cd16, Cd17, Cd18, Cd20, Cd22,		Cer. Cap - 100nF, 25V, XR7, 0805			
9	1	[Main]-Cd21		Cer. Cap - 100nF, 25V, XR7, 0805 (DNP when AMC1204 is used)			
10	1	[Main]-Cd14		Cer. Cap - 470nF, 25V, XR7, 0805			
11	1	[Main]-Cd19		Cer. Cap - 1uF, 25V, XR7, 0805			

12	2	[Main]-C9,C10		Cer. Cap - 10pF, 25V, X5R, 0805			
13	2	[Main]-C8		Cer. Cap - 330pF, 25V, X5R, 0805			
14	7	[Main]-R1,R2,R3,R4,R5,R6,R7		Res. - 15K, 1%,1/8W, 0805			
15	1	[Main]-R57		Res. 10K, 5%, 1/8W, 0805			
16	12	[Main]-R24, R31, R32, R33, R35, R38, R39, R42, R45, R54, R55, R56		Res. -0R ,1/8W, 0805			
17	1	[Main]-R53		Res. -0R ,1/8W, 0805 (DNP when AMC1304 is used)			
18	19	[Main]-R17, R18, R19, R20, R21, R22, R23, R25, R26, R27, R28, R29, R30, R34, R36, R40, R41, R43, R44		DNP : Res. -0R ,1/8W, 0805, Determines isolation settings !! Consult before populating			
19	2	[Main]-RS1 , RS2		Res. - 20mOhms, 1%, 3W, 2512			CRA2512-FZ-R020ELFCT-ND
20	2	[Main]-PR1, PR2		Power Resistor 150K, 1/2W			541-150KVCT-ND
21	8	[Main]-R8,R9,R10,R11,R12,R13,R14,R15		Res - 0E, 1/4W, 1206			
22	2	[Main]-R16, R37		Res. 1K ,1/8W, 0805			
23	2	[Main]-R47, R48		Res. 1M ,1/8W, 1206, 1%			
24	1	[Main]-R49		Res. 1.5K ,1/8W, 1206, 1%			
25	1	[Main]-R50		Res. 1.5K ,1/8W, 0805, 1%			
26	2	[Main]-R51, R52		Res. 12R ,1/8W, 0805, 1%			
27	1	[Main]-L1		INDUCTOR 22UH 13MA 0805			490-4030-1
28	1	[Main]-LD1		LED, green, 0805 Mfr # PG1112H-TR		PG1112H-TR	404-1021-1-ND
29	1	[Main]-P1		CONN AC RECEPT 7MM R/A RND PCB			Q218-ND
30		[Main]-J1,J2,J3,J4,J5,J6,J7,J8,H9,J10,J12, J13, J14, J15, J16, J19, J20, J21		Standard 0.1'' SIL headers, cut to fit, total needed 1x2			
31		[Main]-H5, J17, J9, H10, J18		Standard 0.1'' SIL headers, cut to fit, total needed 1x3			
32	4	[Main]-H3, H4, H6, H15		8 pos keyed 0.1" vertical header 2x4			70246-0801

33	1	[Main]-H13		20 pos keyed 0.1" vertical header 2x10			70246-2002
34		[Main]-H2		Standard 0.1'' SIL headers, cut to fit, total needed 1x5			
35	1	[Main]-TB1		3 input connector for connecting Motor			ED1610-ND
36	1	[Main]-H14		Terminals (2 screw) 5.08mm, 7.5mm wide			ED1975-ND
37	3	[Main]-H1, H7, H8		180 pin (120 + 60) HSEC8 socket, samtec Mfr # HSEC8-130-01-L-DV-A & HSEC8-160-01-L-DV-A-BL		HSEC8-130-01-L-DV-A & HSEC8-160-01-L-DV-A-BL	SAM8081-ND & SAM8084-ND
38	3	[Main]-BS1,BS2,BS3		Banana Connector and Screws			501-1115-ND
39	1	M1-C1		CAP FILM 0.047UF 760VDC RADIAL			495-3972-ND
40	2	M1-C2,C3		CAP FILM 4n7/2KVdc RADIAL			399-5901-nd
41	1	M1-F1		Fuse Holder			486-1160-ND
42	1	M1-Fuse-F1		FUSE 250V IEC SLO 5X20MM 10A			F2425-ND
43	1	M1-RT1		CURRENT LIMITR INRSH 10 OHM 15A - SL32 10015		SL32 10015	570-1058-ND
44	1	M1-VAR1		VARISTOR 275V RMS 10MM RADIAL			495-1433-ND
45	1	M1-DB1		RECT BRIDGE 35A 600V - GBPC3506W-G		GBPC3506W-G	641-1384-ND
46	1	M1-T1		8121-RC, CHOKE COMM MODE W/HDR 1mH 20A			M8916-ND
47	2	M1-L1, L2		INDUCT PWR 7.8UH TH			553-1503-ND
48	1	M2-M2		400V to 15V auxially power supply, PR902		PR902	
49	1	M8-M8		400V to 15V auxially power supply, PR902		PR902	
50	1	M3-C1		Cer. Cap - 22u, 25V, X5R, 1206			
51	1	M3-C2		Cer. Cap - 10u, 25V, X5R, 1206			
52	1	M3-C3		Cer. Cap - 4u7, 25V, X5R, 0805			
53	1	M3-C4		Cer. Cap - 0.1uf, 25V, X5R, 0805			
54	2	M3-C5,C6		Elec. Cap - 330uf/ 63V, Alum, radial			P15739CT-ND
55	1	M3-R1		Res. - 330R, 1%, 0.1W, 0805			
56	1	M3-R2		Res. - 470R, 5%, 0.1W, 0805			
57	1	M3-LD1		LED, green, 0805			404-1021-1-ND
58	1	M3-SW1		Toggle Switch - Miniature, SPDT			CKN1002-ND

59	1	M3-M1		Power Module - PTH08080		PTH08080	296-20432-ND
60	1	M3-U1		LDO - 3.3V - TPS79533			296-13810-1-ND
61	1	M3-JP1		Power jack 2.1 x 5.5 mm			CP-002AH-ND
62	1	M9-C1		Cer. Cap - 22u, 25V, X5R, 1206			
63	1	M9-C2		Cer. Cap - 10u, 25V, X5R, 1206			
64	1	M9-C3		Cer. Cap - 4u7, 25V, X5R, 0805			
65	1	M9-C4		Cer. Cap - 0.1uf, 25V, X5R, 0805			
66	2	M9-C5,C6		Elec. Cap - 330uf, 63V, Alum, radial			P15739CT-ND
67	1	M9-R1		Res. - 330R, 1%, 0.1W, 0805			
68	1	M9-R2		Res. - 470R, 5%, 0.1W, 0805			
69	1	M9-LD1		LED, green, 0805			404-1021-1-ND
70	1	M9-SW1		Toggle Switch - Miniature, SPDT			CKN1002-ND
71	1	M9-M1		Power Module - PTH08080		PTH08080	296-20432-ND
72	1	M9-U1		LDO - 3.3V - TPS79533		TPS79533	296-13810-1-ND
73	1	M9-JP1		Power jack 2.1 x 5.5 mm			CP-002AH-ND
74	4	M4-C1,C2,C3,Cd5		Elec. Cap - 100uF, 50V, 20%, SMD			565-2133-1-ND
75	8	M4-C4,C5,C6, Cd1,Cd2,Cd3,Cd4,Cd7		Cer. Cap - 2.2uF, 25V, X5R, 0805			
76	1	M4-Cd10		Cer. Cap - 2.2uF, 25V, X5R, 1206			
77	6	M4-C7,C8,C9,C10,C11,C12		Cer. Cap - 220p, 50V, X7R, 0805			
78	1	M4-C13		Cer. Cap - 22nF, 25V, X5R, 0805			
79		M4-C15, C16, C17,C18		DNP			
80	4	M4-C21-24		Cer. Cap - 47nF, 50V, 5%, 0805			
81	4	M4-Cd6,Cd8,Cd9,Cd12		Cer. Cap - 100nF, 50V, XR7, 0805			
82	1	M4-Cd11		Cer. Cap - 4.7uF, 25V, X7R, 0805			
83	3	M4-D1,D2,D3		US1J-13-F, Diode Ultra Fast SW 600V 1A		US1J-13-F	US1J-FDICT-ND
84	3	M4-D4,D5,D6		SMAZ16-TP, Diode Zener 1W 16V SMA		SMAZ16-TP	SMAZ16-FDICT-ND

85	3	M4-R1,R2,R3		Res. 10R, 5%, 0.25W, 1206 SMD			
86	6	M4-R4,R5,R6,R7,R8,R9		Res. 120R, 5%, 0.25W, 0805			
87	3	M4-R10,R11, R39		Res. - 20mOhms, 1%, 3W, 2512		2512	CRA2512-FZ-R020ELFCT-ND
88	8	M4-R47-R50, R12, R31, R58, R59		Res. - 0R, 5%, 0.1W, 0805			
89	1	M4-R13		Res. - 100R, 1%, 1/8W, 0805			
90	6	M4-R14,R16,R17,R33,R34,R41		Res. - 221R, 1%, 1/8W, 0805			
91	3	M4-R15,R30,R46		Res. - 300R, 1%, 1/8W, 0805			
92	4	M4-R19,R22,R25,R36		Res. - 300K, 1%, 1/3W, 1206 SMD			
93	7	M4-R18,R29,R32,R35,R40,R42,R54		Res. - 2K, 1%, 1/8W, 0805			
94	6	M4-R43-45, R51-53		Res. - 22K, 1%, 1/8W, 0805			
95	4	M4-R20,R23,R26,R37		Res. - 820K, 1%, 1/4W, 1206			
96	4	M4-R21,R24,R27,R38		Res. - 9.09K, 1%, 1/4W, 1206			
97	2	M4-R28,R56		Res. - 2.7K, 1%, 1/8W, 0805			
98	2	M4-R55,R57		Res. - 29.4K, 1%, 1/8W, 0805			
99	1	M4-U1		PS21765, MOD IPM 600V 20A MINI DIP		PS21765	835-1037-ND
100	1	M4-U2		1.8V Voltage Reference Chip, REF3318AIDBZT SOT23-3		REF3318AIDBZT	296-22637-1-ND
101	2	M4-U3, U4		OPA2350, CMOS Dual Opamp 8-Soic		OPA2350	OPA2350UA-ND
102		M4-J1-4		Standard 0.1'' SIL headers, cut to fit, total needed 1x2			
103	1	M4-HS1		Heat sink - 0.25" aluminum plate for board size (10.925" x 8.125")			
104	1	M5-Cd1		Cer. Cap - 2.2uF, 25V, X5R, 0805			
105	5	M5-Cd2,Cd3,Cd5, C1, C2		Cer. Cap - 100nF, 25V, XR7, 0805			
106	2	M5-Cd4, Cd6		Cer. Cap 10nF, 25V, X5R, 0805			
107	2	M5-N1,N2		Current Sensor Hall effect, LTS 6-NP / CAS 6-NP		LTS 6-NP / CAS 6-NP	398-1087-5-ND
108	1	M5-U1		OPA2350, CMOS Dual Opamp 8-Soic		OPA2350	OPA2350UA-ND
109	4	M5-R1,R3, R7, R5		Res. - 5K, 1%, 1/8W, 0805			

110	4	M5-R2, R4, R6, R8		Res. - 3.3K, 1%, 1/8W, 0805			
111	2	M5-R9, R10		Res. - 10R, 1%, 1/8W, 0805			
112	1	M6-Cd1		Cer. Cap - 220nF, 16V, X7R, 0603			
113	2	M6-Cd2,Cd3		Cer. Cap - 100nF, 50V, XR7, 0603			
114	1	M6-Cd4		Cer. Cap - 1uF, 50V, XR7, 0603			
115	2	M6-C1,C2		Cer. Cap - 10nF, 50V, X7R, 0603			
116	2	M6-R1,R2		Res. - 100R, 5%, 0.1W, 0603			
117	1	M6-R3		Res. 1K, 1%, 0.1W, 0603			
118	1	M6-R4		Res. - 22K, 1%, 1/8W, 0603			
119	1	M6-U1		IC Comparator 8 SOIC -TLV3502AID		TLV3502AID	296-18147-1-ND
120	1	M6-U2		IC 3-INPUT OR GATE SOT-23-6, SN74LVC1G332		SN74LVC1G332	296-18587-1-ND
121	1	M6-U3,		IC POS-EDGE-TRIG D F-F-8-US8,SN74AUP1G74DCUR		SN74AUP1G74DCUR	296-19761-1-ND
122	2	M7-M1,M2		CONV DC-DC MINI 1W 3KVDC ISOL, DCH010512DN7(5V->12V), DCH010505SN7 (5V->5V)		DCH010512DN7	296-20638-ND
123	2	M7-U1,U2		IC AMC1204DW -Isolated SDM 16SOIC		AMC1204DW	296-28557-ND
124	4	M7-L1, L2, L3,L4		INDUCTOR 22UH 13MA 0805			490-4030-1
125		M7-D1,D2		Zener Diode 5.6V - DNP			
126	4	M7-Cd5,Cd6,Cd7,Cd8		Cer. Cap - 1uF, 25V, X5R, 0805			
127	4	M7-Cd1,Cd3,Cd2,Cd4		Cer. Cap - 100nF, 25V, X5R, 0805			
128	2	M7-Cd9, Cd10		Cer. Cap - 100nF, 25V, X5R, 0805 (DNP when AMC1204 is used)			
129	2	M7-C1,C4		Cer. Cap - 330pF, 25V, X5R, 0805			
130	4	M7-C2,C3,C5,C6		Cer. Cap - 10pF, 25V, X5R, 0805			
131	4	M7-R2,R3,R5,R6		Res. - 12R, 1%, 1/8W, 0805			
132	2	M7-R1,R4		Res. 0R,1%, 1/8W, 0805 (DNP when AMC1304 is used)			
133	1	M10-U1		TXB0106PWR, IC 6BIT NON-INV TRANSLTR 16TSSOP		TXB0106PWR	296-23759-1-ND
134	2	M10-Cd1, Cd2		Cer. Cap. 0.1uF, 25V, 0805, X5R			

135	3	M10-C1, C2, C3		Cer. Cap. 10nF, 25V, 0805, X5R			
136	3	M10-R1, R2, R3		Res. 47K, 5%, 1/8W, 0805			
137	1	M11-C1		Cer. Cap - 1u, 25V, X5R, 0805			
138	1	M11-C2		Cer. Cap - 47n, 25V, X7R, 0805			
139	1	M11-C3		Cer. Cap - 1n2, 25V, X7R, 0805			
140	1	M11-C4		Cer. Cap - 4n7, 25V, X7R, 0805			
141	2	M11-C5,C6		Cer. Cap - 220p, 25V, X7R, 0805			
142	4	M11-C7,C8,C13,C18		Cer. Cap - 1n, 25V, X7R, 0805			
143	2	M11-C9,C14		Cer. Cap - 47p, 25V, X7R, 0805			
144	4	M11-C10,C11,C15,C16		Cer. Cap - 330p, 25V, X7R, 0805			
145	7	M11-C12,C17,C19,Cd1,Cd3,Cd4,Cd6		Cer. Cap - 100n, 25V, X7R, 0805			
146	2	M11-Cd2,Cd5		Cer. Cap - 2u2, 25V, X5R, 0805			
147	2	M11-L1,L3		Inductor Bead, 60Ohm, 0805			
148	1	M11-L2		Res. - 0R0, 0805			
149	2	M11-R1,R24		Res. - 47R, 1%, 0.1W, 0805			
150	2	M11-R2,R3		Res. - 3K3, 1%, 0.1W, 0805			
151	2	M11-R4,R9		Res. - 68K, 1%, 0.1W, 0805			
152	2	M11-R5,R7		Res. - 5K1, 1%, 0.1W, 0805			
153	8	M11-R6,R8,R13,R14,R19,R20,R22,R23		Res. - 10K, 1%, 0.1W, 0805			
154	2	M11-R10,R16		Res. - 47K, 1%, 0.1W, 0805			
155	4	M11-R11,R12,R17,R18		Res. - 11K, 1%, 0.1W, 0805			
156	2	M11-R15,R21		Res. - 2K, 1%, 0.1W, 0805			
157	1	M11-U1		IC OPAMP GP R-R 18MHZ LN OPA2209 8SOIC		OPA2209	296-27783-1-ND
158	1	M11-U2		IC OPAMP GP R-R 5.1MHZ TLV2772 8SOIC		TLV2772	296-10677-1-ND
159	1	M11-U3		TLV2771 in SOT23-5 footprint		TLV2771	296-1347-1-ND
160	4	M12-Cd1-Cd4		Cer. Cap - 100nF , 25V, 0805			
161	5	M12-C1-C5		Cer. Cap - 330pF, 25V, X5R, 0805			

162	3	M12-R1,R2,R3		Res. - 10R, 5%, 0.1W, 0805			
163	1	M12-R4		Res. - 120R, 1%, 0.1W, 0805			
164	1	M12-R5		Res. - 47K, 5%, 0.1W, 0805			
165	2	M12-R6,R7		Res. - 150K, 5%, 0.1W, 0805			
166	1	M12-U1		Voltage Translator, 4 channel, TXB0104 - TSSOP-14		TXB0104	296-21929-1-ND
167	2	M12-U2,U3		Transceiver, RS485 Half Duplex, SOIC-8		SN65HVD3088ED	296-17172-5-ND
168	1	M12-U4		High Side Switch, TPS27082L - SOT-23-6		TPS27082L	296-35595-1-ND
169	3	M13-C1-C3		Cer. Cap - 10pF, 25V, NPO, 0805			
170	3	M13-Cd1-Cd3		Cer. Cap - 100nF , 25V, 0805			
171	8	M13-R1-R4,R9,R10,R16,R17		Res. - 20K, 1%, 0.1W, 0805			
172	6	M13-R5-R8,R11,R12		Res. - 10K, 1%, 0.1W, 0805			
173	3	M13-R13-R15		Res. - 120R, 1%, 0.1W, 0805			
174	2	M13-U1,U2		OpAmp OPA2350, SOIC-8		OPA2350	OPA2350UA-ND

CNCD-0 Item #	QTY	Reference	Value	Part Description and Value	Mfg	Manufacturer Part Number	Digikey Part #
CNCD-01	69	[CNCD]-A:C1 A:C6-12 A:C14 A:C16-17 A:C20-30 C1-3 C7 C10-14 C43 C45 C48-64 C66 C75-80 C83-89 C95 C97-100	100n	CAP CER 16V 10% X7R 0402			
CNCD-02	1	[CNCD]-A:C4	10n	CAP CER 16V 10% X7R 0402			
CNCD-03	2	[CNCD]-C4-5	1n	CAP CER 16V 10% X7R 0402			
CNCD-04	1	[CNCD]-C46	470n	CAP CER 6.3V 10% X5R 0402			
CNCD-05	2	[CNCD]-C6 C67	DNP	CAP CER 16V 10% X7R 0402			
CNCD-06	2	[CNCD]-C8-9	15p	CAP CER 50V NP0 0402			
CNCD-07	2	[CNCD]-A:C18-19	27p	CAP CER 50V NP0 0402			
CNCD-08	1	[CNCD]-C68	33p	CAP CER 50V NP0 0402			
CNCD-09	4	[CNCD]-A:C2 C71-72 C74	10u	CAP CER 6.3V 20% X5R 0603			

CNCD-10	4	[CNCD]-C44 C82 C91 C96	2u2	CAP CER 10V 20% X5R 0603			
CNCD-11	3	[CNCD]-A:C5 A:C13 A:C15	4u7	CAP CER 6.3V 10% X5R 0603			
CNCD-12	24	[CNCD]-C19-42	DNP	CAP CER 16V 10% X7R 0603			
CNCD-13	3	[CNCD]-C70 C73 C94	10u	CAP CER 10V 20% X5R 0805			
CNCD-14	3	[CNCD]-C47 C65 C69	22u	CAP CER 6.3V 20% X5R 0805			
CNCD-15	6	[CNCD]-C15-18 C81 C90	2u2	CAP CER 10V 20% X5R 0805			
CNCD-16	1	[CNCD]-C92	DNP	CAP TANT 20% 1206			
CNCD-17	1	[CNCD]-J1	HEADER_HSEC8-180_EDGE	180 pin (120 + 60) HSEC8 fingers; mates with samtec connectors			
CNCD-18	2	[CNCD]-A:D3-4	BLUE	LED BLUE 0805 SMD, Clear, 470nm			
CNCD-19	2	[CNCD]-A:D2 LD1	GREEN	LED GREEN 0805 SMD, Diffused, 567nm			
CNCD-20	2	[CNCD]-LD2-3	RED	LED RED 0805 SMD, Diffused, 647nm			
CNCD-21	1	[CNCD]-R66	200K	RES 1/16W 0.1% 0402 SMD			
CNCD-22	1	[CNCD]-R65	205K	RES 1/16W 1% 0402 SMD			
CNCD-23	1	[CNCD]-R58	22K	RES 1/16W 1% 0402 SMD			
CNCD-24	1	[CNCD]-R56	2K	RES 1/16W 1% 0402 SMD			
CNCD-25	1	[CNCD]-R61	340K	RES 1/16W 1% 0402 SMD			
CNCD-26	2	[CNCD]-R1-2	4K7	RES 1/16W 1% 0402 SMD			
CNCD-27	1	[CNCD]-R63	75K	RES 1/16W 0.1% 0402 SMD			
CNCD-28	7	[CNCD]-A:R7 A:R10 R16 R59 R69-70 R78	0	RES 1/16W 5% 0402 SMD			
CNCD-29	2	[CNCD]-A:R3 R72	100K	RES 1/16W 5% 0402 SMD			
CNCD-30	13	[CNCD]-A:R2 A:R4 A:R6 A:R8 A:R15 A:R17 R26-27	10K	RES 1/16W 5% 0402 SMD			

		R29 R62 R71 R73-74					
CNCD-31	4	[CNCD]-A:R5 A:R9 A:R11-12	1K	RES 1/16W 5% 0402 SMD			
CNCD-32	4	[CNCD]-A:R16 R11 R24-25	2K2	RES 1/16W 5% 0402 SMD			
CNCD-33	7	[CNCD]-R5-10 R14	39	RES 1/16W 5% 0402 SMD			
CNCD-34	1	[CNCD]-R22	510K	RES 1/16W 5% 0402 SMD			
CNCD-35	2	[CNCD]-R18-19	56K	RES 1/16W 5% 0402 SMD			
CNCD-36	4	[CNCD]-A:R1 R12-13 R60	680	RES 1/16W 5% 0402 SMD			
CNCD-37	4	[CNCD]-A:R13-14 R15 R28	DNP	RES 1/16W 5% 0402 SMD			
CNCD-38	1	[CNCD]-R21	120K	RES 1/10W 1% 0603 SMD			
CNCD-39	1	[CNCD]-R23	560K	RES 1/10W 1% 0603 SMD			
CNCD-40	1	[CNCD]-R17	649K	RES 1/10W 1% 0603 SMD			
CNCD-41	1	[CNCD]-R20	750K	RES 1/10W 1% 0603 SMD			
CNCD-42	27	[CNCD]-R30-42 R44-55 R67-68	0	RES 1/10W 5% 0603 SMD			
CNCD-43	3	[CNCD]-R75-77	100K	RES 1/10W 5% 0603 SMD			
CNCD-44	4	[CNCD]-R3-4 R43 R64	DNP	RES 1/10W 5% 0603 SMD			
CNCD-45	1	[CNCD]-R57	0	RES 1/8W 5% 0805 SMD			
CNCD-46	9	[CNCD]-A:TP1-2 TP1-7		Via, 20 ID, 40 OD (mil)			
CNCD-47	1	[CNCD]-U5	micro-SD	micro SD Connector+Ejector, 10 (8+2) positions, SMT-top		101-00581-59	101-00581-59-1-ND
CNCD-48	1	[CNCD]-A:C31	10n	CAP CER 1.5KV 10% X7R 1812		1812SC103KAT1A	478-4735-1-ND
CNCD-49	1	[CNCD]-J8		USB micro AB Female USB2.0		1981584-1	A97799CT-ND
CNCD-50	2	[CNCD]-A:SW1 SW1	218-2LPST	2xSPST DIP switch SMT, half-pitch		218-2LPST	CT2182LPST-ND
CNCD-51	1	[CNCD]-SW2	4xSPST	4xSPST DIP Switch		281-4LPST	CT2184LPST-ND
CNCD-52	1	[CNCD]-X1	20MHz, 20ppm	20MHz Crystal, 20ppm		7B-20.000MEEQ-T	887-1303-1-ND
CNCD-53	1	[CNCD]-A:U5		IC EEPROM 2KBIT 3MHZ 8SOIC		93LC56C-I/SN	93LC56C-I/SN-ND

CNCD-54	2	[CNCD]-L5-6	60Ohm	FERRITE 3A 60OHM@100MHz 0805 SMD		BKP2125HS600-T	587-1932-1-ND
CNCD-55	2	[CNCD]-L3-4	220Ohm	FERRITE 2A 220OHM@100MHz 0805 SMD		BLM21PG221SN1D	490-1054-1-ND
CNCD-56	2	[CNCD]-SW3-4	CAS-D20TA	Switch SPDT, 2 position		CAS-D20TA	CASD20JCT-ND
CNCD-57	1	[CNCD]-A:X1	12 MHz	CRYSTAL 12.000 MHZ 20PF SMD		ECS-120-20-30B-TR	XC1118CT-ND
CNCD-58	1	[CNCD]-A:U4		IC USB HS DUAL UART/FIFO 64-QFN		FT2232HL	768-1024-1-ND
CNCD-59	2	[CNCD]-A:L1-2		FERRITE 500MA 600 OHM 0805 SMD		HZ0805E601R-10	240-2399-1-ND
CNCD-60	5	[CNCD]-A:U6-8 A:U10-11		IC DGTL ISOLATOR 25MBPS 2CH 8SOIC	TI	ISO7220CD	296-21953-1-ND
CNCD-61	1	[CNCD]-U12		IC OPAMP GP R-R 15MHZ QUAD 14TSSOP	TI	LMP7709MT/NOPB	LMP7709MT/NOPB-ND
CNCD-62	6	[CNCD]-J2-7	1x3 HDR	Header Male; 1x3, 2mm pitch		M22-2510305	952-1312-ND
CNCD-63	3	[CNCD]-A:D1 D1-2		DIODE SCHOTTKY 10V 1A POWERMITE		MBRM110ET1G	MBRM110ET1GOSCT-ND
CNCD-64	1	[CNCD]-U16	NTA7002NT1G	N-channel MOSFET 30V 0.154A		NTA7002NT1G	NTA7002NT1GOSCT-ND
CNCD-65	6	[CNCD]-U6-11	NUP4201MR6T1G	TVS 4-ch Diode Array, 5V breakdown		NUP4201MR6T1G	NUP4201MR6T1GOSCT-ND
CNCD-66	1	[CNCD]-U13		IC, Voltage Reference, 3.0V, 0.2%, 14uVpp noise	TI	REF3030AIDBZR	296-26323-1-ND
CNCD-67	1	[CNCD]-U17		IC, Voltage Reference, 3.3V, 0.2%, 14uVpp noise	TI	REF3033AIDBZR	296-26324-1-ND
CNCD-68	1	[CNCD]-A:U9	3-State Buffer	3-State Buffer, 2 elements x 4 bits	TI	SN74ALVC244PWR	296-5136-1-ND
CNCD-69	1	[CNCD]-A:U3		IC GATE NAND QUAD 2INP 14TSSOP	TI	SN74HC03PW	296-29731-1-ND
CNCD-70	1	[CNCD]-U2	SN74LVC2G07DBVR	Buffer Line Driver, non-inverting, 32mA	TI	SN74LVC2G07DBVR	296-13494-1-ND

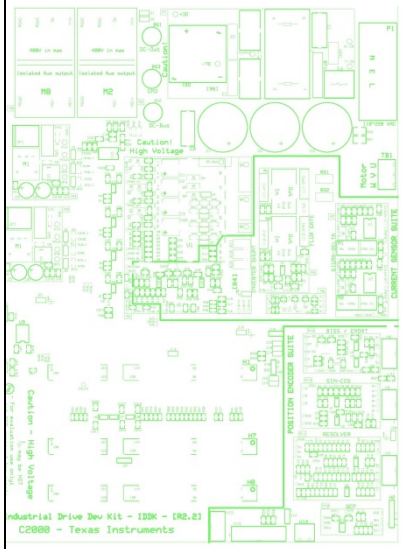
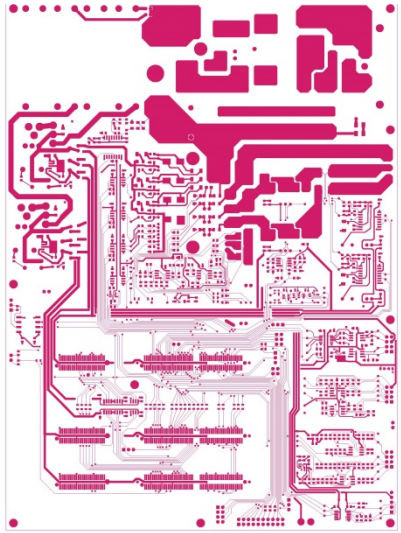
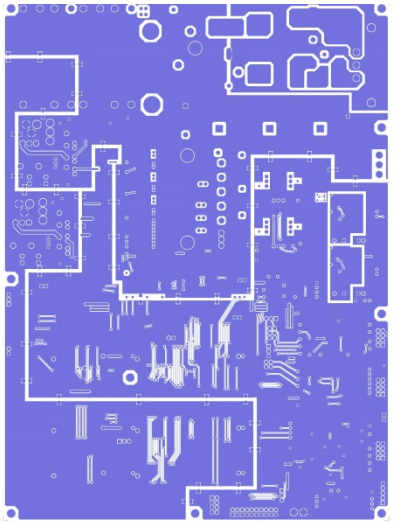
CNCD-71	1	[CNCD]-A:C3	47u	CAP TANT 20% 0805 6.3V		TCTP0J476M8R	511-1682-1-ND
CNCD-72	1	[CNCD]-C93	68u	CAP TANT 10V 20% 1206		TLJA686M010R1500	478-4925-1-ND
CNCD-73	1	[CNCD]-U1		MCU F2837x 337pin ZWT BGA	TI	TMS320F28377DZWT	
CNCD-74	1	[CNCD]-A:U2		IC ESD-PROT ARRAY 2CH SOT-5	TI	TPD2E001DRLR	296-21883-1-ND
CNCD-75	1	[CNCD]-U15	TPS2051BDBVR	High-Side Power Distribution Switch	TI	TPS2051BDBVR	296-21265-1-ND
CNCD-76	1	[CNCD]-U3		IC SVS Adjustable SON-6/DRY; PushPull; ActiveLow	TI	TPS3895ADRY	296-29806-1-ND
CNCD-77	1	[CNCD]-U4		IC SVS Adjustable SON-6/DRY; OpenCollector	TI	TPS3897ADRY	296-29810-1-ND
CNCD-78	1	[CNCD]-U14		IC Dual Step Down Converter, 2.25MHz, 600mA/1A	TI	TPS62420DRC	296-25650-1-ND
CNCD-79	1	[CNCD]-A:U1		IC LDO REG HI-PSRR 3.3V SOT23-5	TI	TPS73033DBV	296-17580-1-ND
CNCD-80	1	[CNCD]-A:J1		CONN RECEPT MINI USB2.0 5POS		UX60-MB-5ST	H2959CT-ND
CNCD-81	1	[CNCD]-L1	2u2	Inductor Power 2.2uH 1.0A SMD 20%		VLF3010AT-2R2M1R0	445-3215-1-ND
CNCD-82	1	[CNCD]-L2	3u3	Inductor Power 3.3uH 0.87A SMD 20%		VLF3010AT-3R3MR87	445-3216-1-ND

7.3 PCB Layout Recommendations

Please refer to the DesignDRIVE Development Kit - IDDK v2.2 Hardware Reference Guide for more information on layout and use considerations.

7.3.1 Layout Prints

To download the Layout Prints for each board, see the design files at http://www.ti.com/tool/DESIGNNUMBER

TOP SILKSCREEN	TOP SOLDER MASK	TOP LAYER	BOTTOM LAYER	BOTTOM SOLDER MASK
				

7.4 Gerber files

To download the Gerber files for each board, see the design files at http://www.ti.com/tool/TIDM-SERVODRIVE

8 Software Files

To download the software files for this reference design, please see the link at http://www.ti.com/tool/TIDM-SERVODRIVE and www.ti.com/tool/DesignDRIVE

9 References

1. Texas Instruments Application Report, Noise Analysis in Operational Amplifier Circuits, SLVA043A, 1999
2. Texas Instruments WEBENCH® Design Center, http://www.ti.com/webench
3. Texas Instruments E2E Community, http://e2e.ti.com/

10 About the Author

Ramesh Ramamoorthy is a Systems Solutions Engineer at Texas Instruments, where he is responsible for developing reference design solutions for motor drive end equipment. Ramesh has been a motor drives and power electronics engineer and has extensive experience designing and developing analog / digital controllers for a variety of motor drive applications. He has also developed a few reference designs in HVAC and home appliance industry. He earned his Master of Technology in Electrical Engineering from the Indian Institute of Technology, Madras, India.

Brian Fortman is responsible for the Industrial Drives and Automation market for C2000™ real-time microcontrollers. Brian has 20+ years of experience in marketing, sales and applications and holds a BSEE from the University of Missouri – Rolla.

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