Conestoga College
Institute of Technology and Advanced Learning

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Revision History

Revision	Description of Change	Effective Date
1	New Document Release	Jan. 16, 2015
2	BOM, schematics and hardware spec updates	Jan. 23, 2015
3	Adding LCD, DAC, Accelerometer. Changes to encoder, BOM and HW reqs	Jan. 30, 2015
4	Adding preliminary PCB layout, updated BOM	Feb. 08,2015

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1. Introduction:

As part of the semester for year 2 for studies in Electronic Systems Engineering it is required to implement a project that will give students the opportunity to study and apply design principles for the creation of embedded systems hardware and software.

Additional tasks that a student will be learning through implementation of the project are:

- Populate and test PCB boards
- Design and simulate test diagnostic systems
- Use schematic capture as well as read specification of parts/systems vendors
- Create PCB manufacturing data
- Create a detailed documentation regarding project specifications and scheduling of the project

2. Scope of the Document:

The scope of the Project Functional Specification document is to present hardware specifications needed to implement the HCS12 embedded PCB. This document will be subjected to numerous revisions as the project progresses and the aspects of the project are added through the semester. This document shall include:

- List of related documents supporting the project
- Cost targets of the components and services needed to finish the project
- Configuration options of the embedded system
- Detailed specification such as:
    - Performance
    - Port usage
    - Communication options
    - External cabling details
    - Physical size and physical constraints
    - Power requirements
- Regulatory requirements
- Reliability and service

3. Chapter I – List of Related Documents

3.1. Purpose:

The purpose of this chapter is to attach documentation related to the project. The documentation will be attached as links. Some documents might require special access permissions to be viewed. Contact document author if issues persist.

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3.2. Documents list:

#	Document tile	Revision	Document purpose	Link
1	LM22675 Specs	L	To present specifications of LM22675	link
2	Project Charter	2.7	To present project IV requirements	link
3	Notes For Design Verification	5.0	MCU pin specifications	link
4	Port Mapping	6	Port mapping and pin outs of the MCU	link
5	PCB tolerances and design requirements	N/A	PCB design and tolerances	link
6	DC motor encoder connections	N/A	Pin out of the DC motor connector	link
7	Board outline	8	PCB outline and connector placements	link
8	Camera conx pinout	2	Camera connection pin out	link
9	Motor encoder	N/A	Motor speed feedback diagram	link
10	MAX3232	7	MAX3232 Data Sheet	link
11	Altium Resource/Documentation	N/A	Webpage for Altium Designer support	link
12	Absolute Maximum Ratings for Soldering SNOA549C	N/A	Soldering ratings for National Semiconductors	link
13	L293DD Driver	N/A	Stepper motor driver specifications	link
14	L6225 Driver	N/A	DC motor driver specifications	link

4. Chapter II – Cost Target

4.1. Purpose:

The purpose of the Cost Target chapter is to track the expenses of the parts and services required to finish the project. This chapter will keep an updated BOM as well as any quotes obtained from the vendors.

4.2. BOM

Designator	Footprint	LibRef	#
C1, C2F_DC1, C_ACC_PF2, C_ENA_DC1, C_ENB_DC1, C_ENC1_F, C_ENC2_F, C_VCP_DC1, C_VDD1, C_VDD2, C_VDDX2, C_VR_PWR, C_VRH2, C_Y1, C_Y2, CBoot_DC1, Cbst_A, Cbst_D, Cin_A, Cin_D, Cinx_A, Cinx_D, Cout_A, Cout_D, CX1, CX2, CX3, CX4	CAPC2012X09M	CAP-X7R-47000pF-50V-±10%, CAP-X7R-.1uF-100V-±10%, CAP-X7R-.1uF-16V-±10%, CAP-X7R-5600pF-50V-±10%, CAP-X7R-5600pF-50V-±10%, CAP-X7R-.1uF-50V-±5%, CAP-X7R-.1uF-50V-±5%, CAP-COG-220pF-50V-±5%, CAP-X7R-.1uF-50V-±5%, CAP-X7R-.1uF-50V-±5%, CAP-X7R-10000pF-50V-±10%, CAP-X7R-.1uF-16V-±10%, CAP-X7R-10000pF-50V-±10%, CAP-COG-22pF-50V-±5%, CAP-COG-22pF-50V-±5%, CAP-X7R-2.2uF-16V-±10%, CAP-X7R-10000pF-50V-±10%, CAP-X7R-10000pF-50V-±10%, CAP-X7R-2.2uF-16V-±10%, CAP-X7R-2.2uF-16V-±10%, CAP-X7R-1uF-16V-±10%, CAP-X7R-1uF-16V-±10%, CAP-X5R-10uF-10V-±10%, CAP-X5R-10uF-10V-±10%, CAP-X7R-4700pF-630V-±10%, CAP-X7R-4700pF-630V-±10%, CAP-X7R-.1uF-16V-±10%, CAP-COG-10000pF-50V-±5%	28
C2, C3, C4, C_BYPASS, C_VDDR, C_VDX1, C_VRH1	CAPACITOR_3MM	Cap Polar-0.33uF-50V, Cap Polar-0.33uF-50V, Cap Polar-0.33uF-50V, Cap Polar-0.1uF-50V, Cap Polar-10uF-16V, Cap Polar-10uF-16V, Cap Polar-10uF-16V	7

C_ACC_PF1	CAPACITOR_5MM	Cap Polar-10uF-35V	1
C_F_DC1	CAPACITOR_6.3MM	Cap Polar-100uF-16V	1
C_in_LVR_5VD, Cout_LVR3V3		CAPACITOR POL	2
D1_2V5_REF		D Zener	1
D1_5V5A, D1_5V5D	DIOM4326X23M	DIODE SCHOTTKY 40V 2A SMA	2
D1_DC1, D2_DC1, D_Reset	zener_sod323	Diode 1N4148	3
H1_BDM	HDR2X3	Header 3X2	1
H1_ENC1	HDR1X4	Header 4	1
H2_ENC2	HDR1X4	Header 4	1
H2_VRH, H3_VRL, H_PLL, H_VDDA, H_XCF, V_BAT	HDR1X2	Header 2	6
H4_LCDHeader	HDR1X16_LCD	Header16_LCD	1
H4_ServoM, H6_DAC	HDR1X3	Header 3	2
J_DB9	DSUB1.385-2H9	D Connector 9	1
L1_A, L1_D	INDP8080X40M	SRN8040	2
L_VDDA	C1210	INDUCTOR	1
PORT_E	HDR1X5	Header 5	1
R1, R1_ACCL, R1_LCD, R2, R2_ACCL, R2_LCD, R3, R3_LCD, R4, R4_LCD, R5, R6, R_ACCL_OUT1, R_ACCL_OUT2, R_BDM, R_DAC, R_ENA_DC1, R_ENB_DC1, R_ENC1_PWR, R_ENC1_TX, R_ENC2_PWR, R_ENC2_TX, R_IRQ, R_LCD_V, R_Pierce_EN, R_RESET, R_S1, R_XIRQ, R_Y1, R_Y2, R_Z_REF, Rfb1_A, Rfb1_D, Rfb2_A, Rfb2_D, RVCP_DC1, RX1	RESC2112X05M	Resistor_10.0K, Resistor_1.00K, Resistor_4.75K, Resistor_10.0K, Resistor_1.00K, Resistor_4.75K, Resistor_10.0K, Resistor_4.75K, Resistor_10.0K, Resistor_4.75K, Resistor_10.0K, Resistor_10.0K, Resistor_10.0K, Resistor_3.09K, Resistor_10.0K, Resistor_10.0K, Resistor_100R, Resistor_100R, Resistor_5.11K, Resistor_475R, Resistor_5.11K, Resistor_475R, Resistor_4.75K, Resistor_221R, Resistor_4.75K, Resistor_10.0K, Resistor_10.0K, Resistor_4.75K, Resistor_10.0K, Resistor_1.02R, Resistor_2.49K, Resistor_1.00K, Resistor_1.00K, Resistor_2.87K, Resistor_2.87K, Resistor_100R, Resistor_5.11K	37
R_Cont	BOURNS_3386F	RPot	1
SW1_RESET	TACT_SWITCH_6MM_SMT	SWITCH_TACTILE	1
U1_ACCL	SOIC127P600X175-	LMC6484_0	1

	14M-NS		
U1_LVR_3V3	MP04A_L	LM1117IMP-ADJ/NOPB	1
U1_Stepper_M	SO20_N	L293DD	1
U2_DC_Motor1	POWERSOP20	L6225	1
U3_DAC	TSOP65P490X110-8M	Max5513-dac	1
U_ACCL	LGA-14-3X5MM	LIS352AR	1
U_CPU1	QUAD.65M/80/WG17.45-HCS12	MC9S12C128MFUE	1
U_ENC2, U_ENC_1	SOIC127P600X175-14M	74ACT14_3	2
U_PS1_A, U_PS1_D	MRA08B_L	LM22675MR-ADJ/NOPB	2
U_RES	SOT95P230X110-3M	DS1813-10	1
U_SER1	NSO16_N	MAX3232CSE	1
Y1	PCBComponent_1	ECS-160-20-5P	1

4.3. Total cost target

Currently the cost target of the finished product is approximately $200. The above estimate presents only the current known parts that must be acquired.

5. Chapter III - Specifications and Performance

5.1. Purpose:

The purpose of this chapter is to present detailed hardware and software specifications regarding configurations, ports usage, cabling details and system communications.

5.2. Hardware Specifications:

5.2.1. Ports:

Module	Port	MODE	Pin
Port T			
• Stepper Motor Coil Pair 2 In	PT7	GPIO OUT	14
• Stepper Motor Coil Pair 2 Out	PT6	GPIO OUT	13
• Stepper Motor Coil Pair 1 In	PT5	GPIO OUT	12
• Stepper Motor Coil Pair 1 Out	PT4	GPIO OUT	11
Port T			
Timer Module			
• RC Servo 2 Out	PT3	Timer Out	8
• RC Servo 1 Out	PT2	Timer Out	7
• DC Motor Encoder 2 In	PT1	Input Capture	6
• DC Motor Encoder 1 In	PT0	Input Capture	5
Port S			
• LED 2 (Green)	PS3	GPIO Out	66
• LED 1 (Green)	PS2	GPIO Out	65
Port S			
Serial Communications Interface (SCI)			
• SCI Transmit	PS1	SCI TX	64
• SCI Receive	PS0	SCI RX	63
Port M			
Serial Peripheral Interface (SPI)			
• SCK	PM5	SPI SCK	70
• MOSI	PM4	SPI MOSI	71
• N_SS	PM3	SPI N_SS	72
• MISO	PM2	SPI MISO	73
Port M			
• CAN_TX	PM1	GPIO Reserved	74
• CAN_RX	PM0	GPIO Reserved	75
Port J			
Serial Peripheral Interface (SPI)			
• SPI_CS2	PJ6	GPIO Out	69
• SPI_CS1	PJ7	GPIO Out	68
Port P			
• Keypad wake	PP7	GPIO Reserved	78
• ROMCTL (Pull up with 10K and connect to header pin for GPIO)	PP6	ROMCTL In	67
Port P			
PWM Module			
• DC Motor 2 PWM	PP5	PWM Out	79
• DC Motor 1 PWM	PP4	PWM Out	80
Port P			
• Unused	PP3	GPIO Unused	1
• Unused	PP2	GPIO Unused	2
• Unused	PP1	GPIO Unused	3
• Unused	PP0	GPIO Unused	4
Port AD			
• Stepper Switch Right	PAD7	GPIO IN	58
• Stepper Switch Left	PAD6	GPIO IN	57
• Unused/Keyboard scan 5	PAD5	GPIO Reserved	56
• Unused/Keyboard scan 4	PAD4	GPIO Reserved	55
• Analog Input 3/Keyboard scan 3	PAD3	Analog In/GPIO	54
• Analog Input 2	PAD2	Analog In	53
• Analog Input 1	PAD1	Analog In	52
• Analog Input 0	PAD0	Analog In	51

Ports assignment cont…

Port A • Unused • LCD_RW • LCD_RS • LCD_E • LCD Data I/O 3 • LCD Data I/O 2 • LCD Data I/O 1 • LCD Data I/O 0	PA7 PA6 PA5 PA4 PA3 PA2 PA1 PA0	GPIO Unused GPIO Out GPIO Out GPIO Out GPIO I/O GPIO I/O GPIO I/O GPIO I/O	48 47 46 45 44 43 42 41
Port B • Unused • Unused • Unused • Unused • DC Motor 2 Direction B • DC Motor 2 Direction A • DC Motor 1 Direction B • DC Motor 1 Direction A	PB7 PB6 PB5 PB4 PB3 PB2 PB1 PB0	GPIO Unused GPIO Unused GPIO Unused GPIO Unused GPIO Out GPIO Out GPIO Out GPIO Out	23 22 21 20 19 18 17 16

5.2.2.Communication and cabling:

- TBD

5.2.3. Hardware configuration:

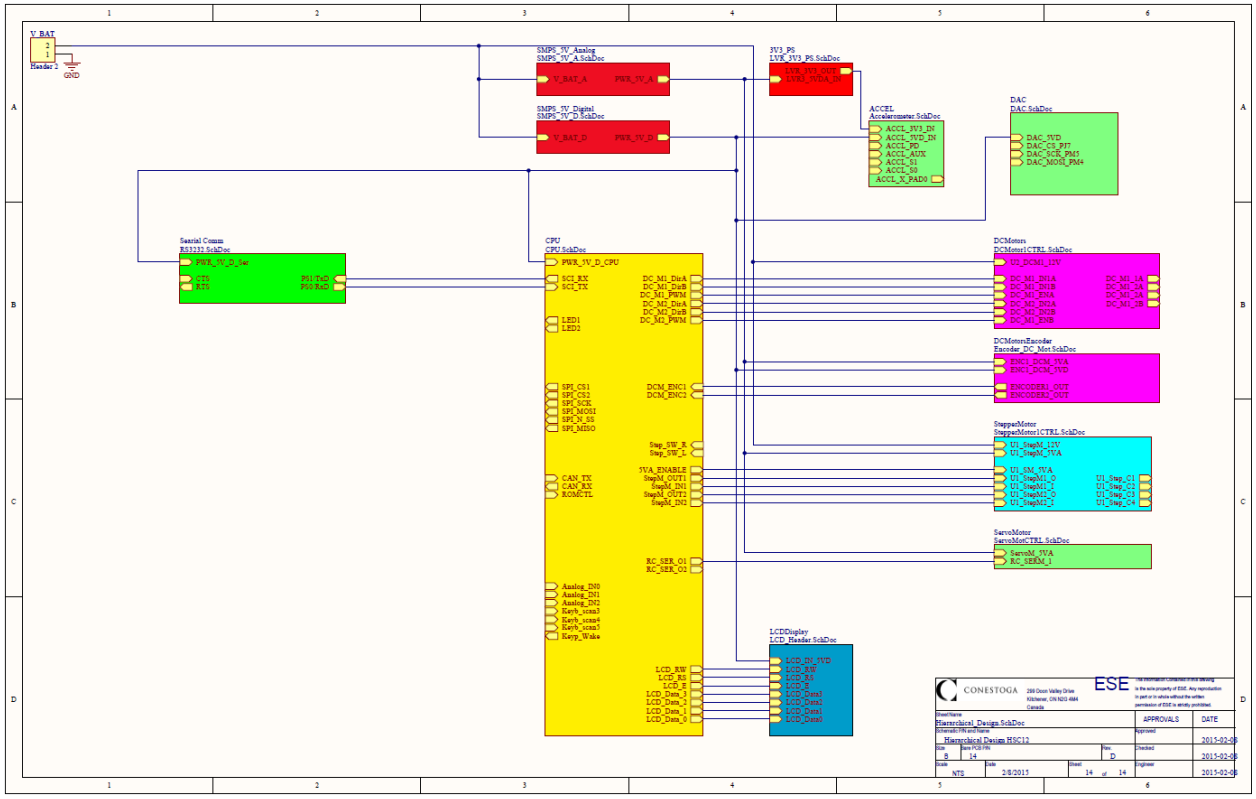
- Pierce oscillator (PE7/XCLKS pulled to ground)
- ModeC=1,ModeB=0,ModeA=0 → Normal single chip, BDM allowed
- UART connection to MAX3232 and ARM mictocontroller

5.2.4. Physical Constraints:

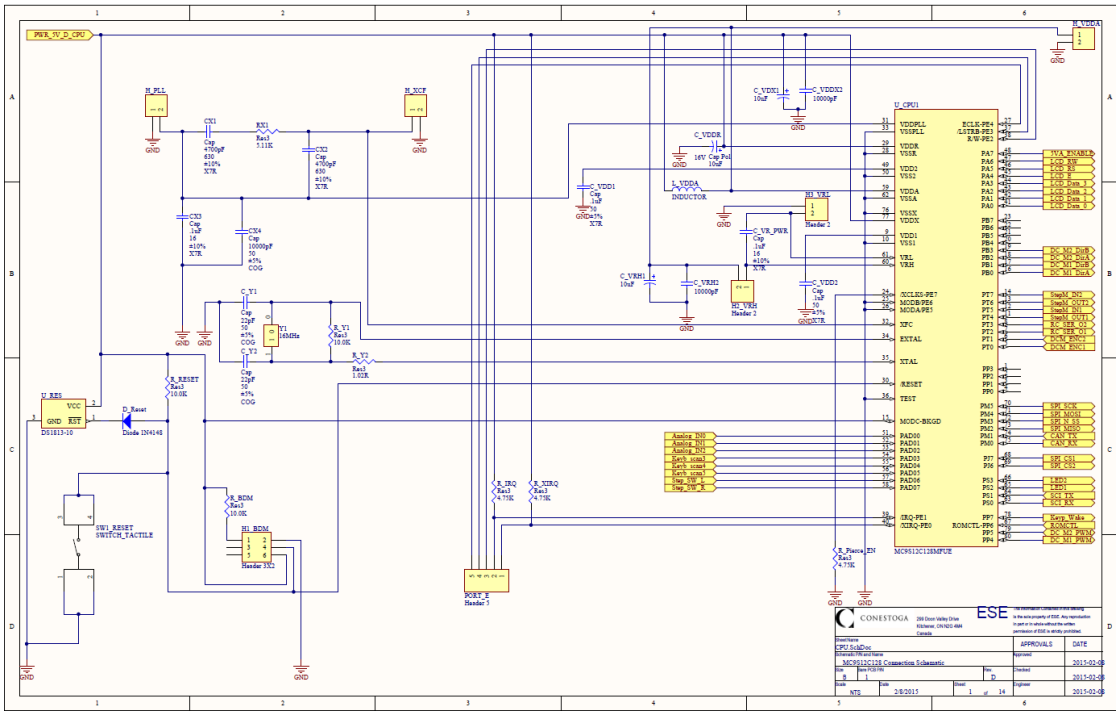
- Refer to refer to document 5 and 7 in 3.2 Documents List for the board physical constraints and layout options. Further details TBD
- Constraints regarding component placement – TBD

5.2.5. PCB Design

- Top Down Representation

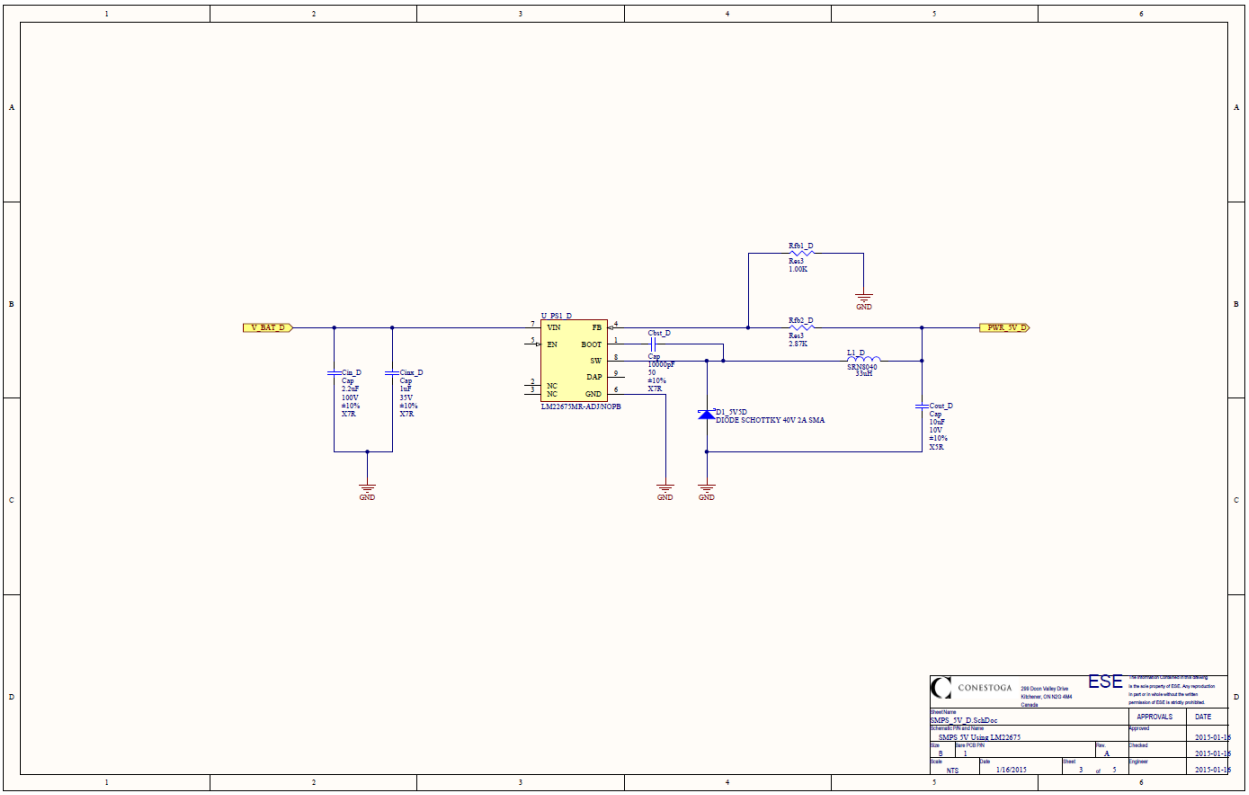


- MCU connections

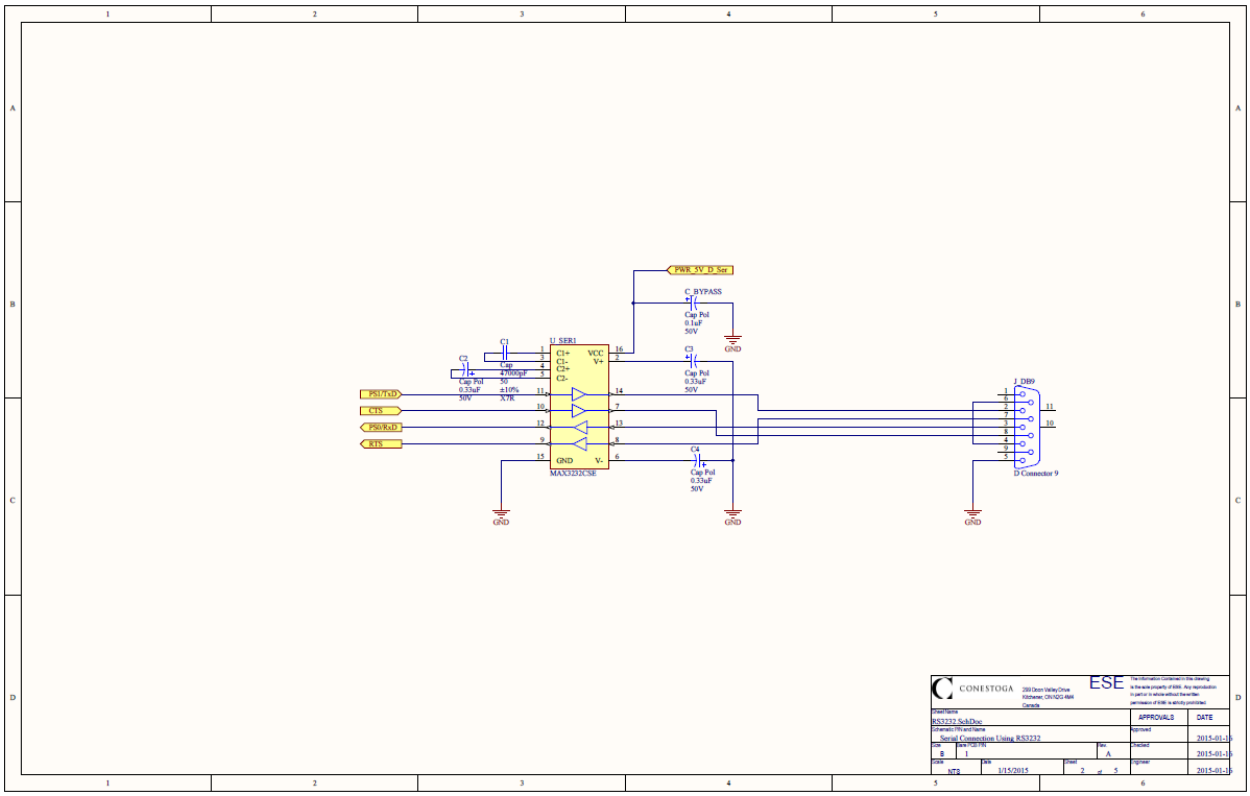


MOD C = 1 ; MOD B = 0 ; MOD A = 0 -> operation type: Normal single chip, BDM allowed

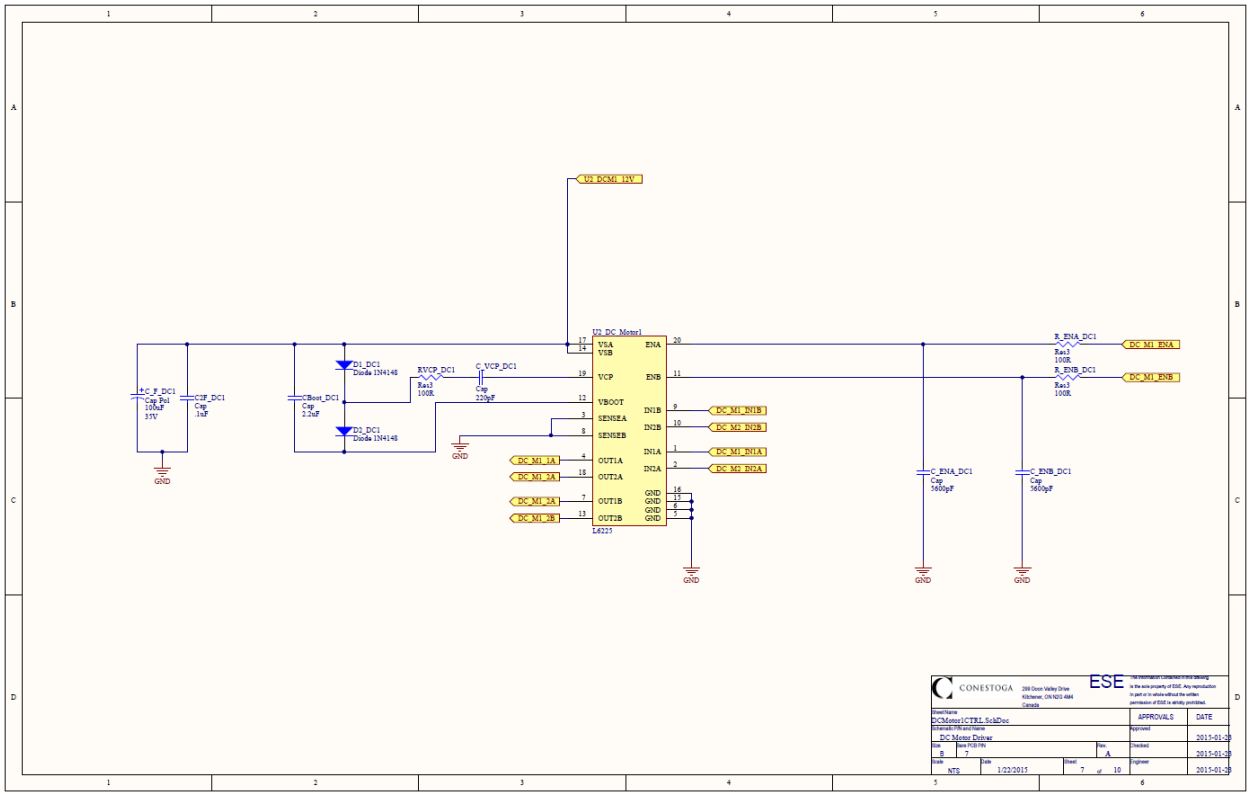
- SMPS 5V power supply



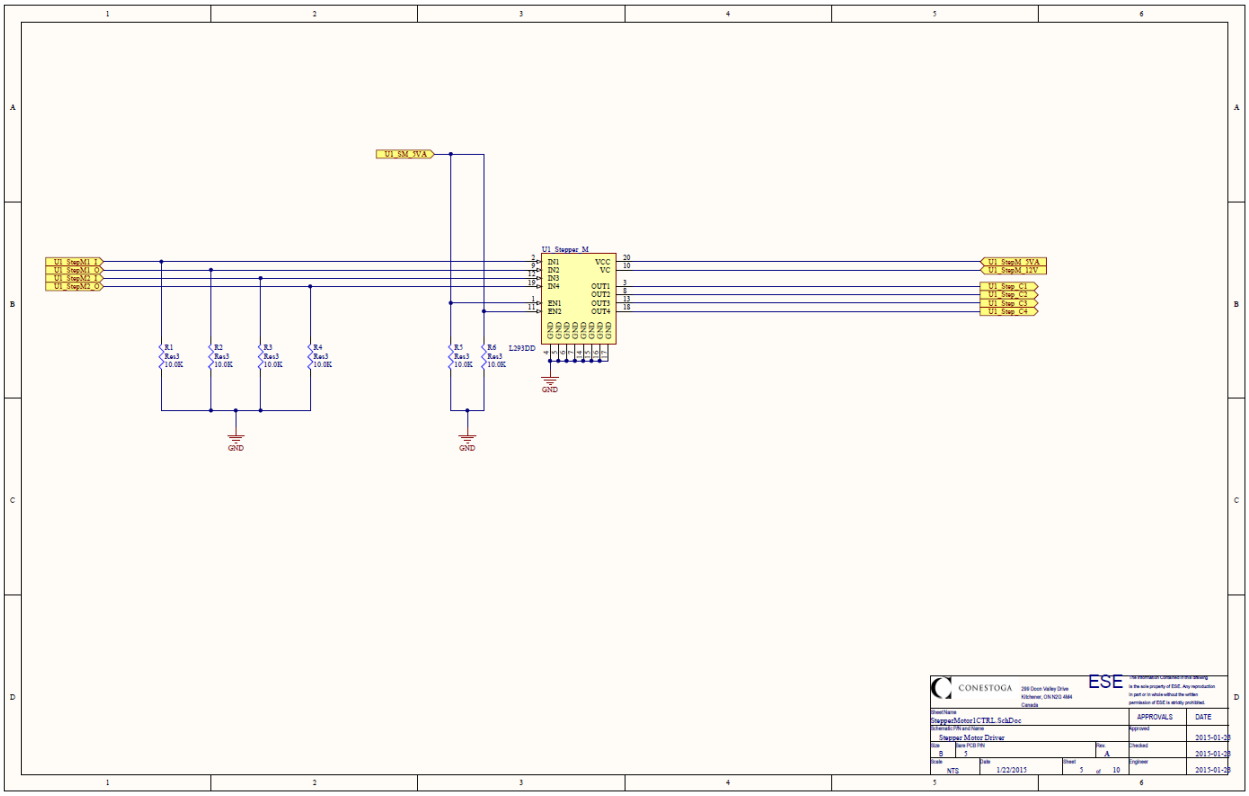
- RS3232 connections



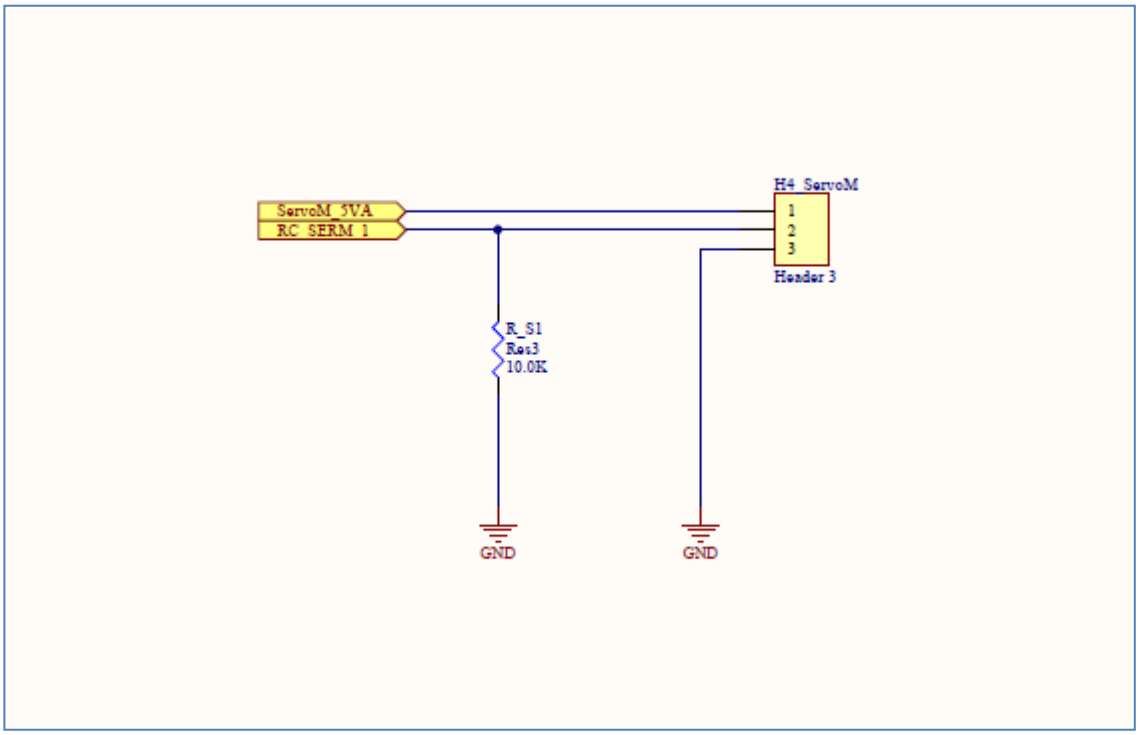
- DC motor driver



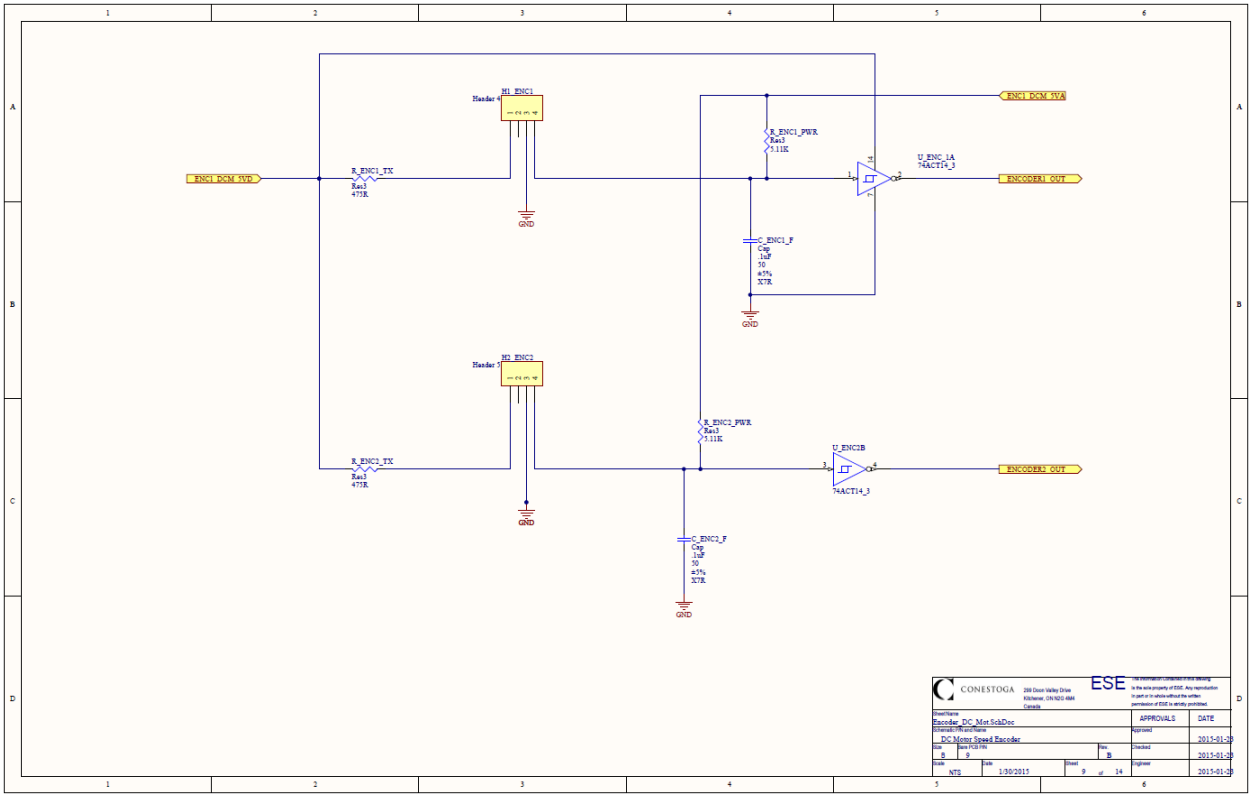
- Stepper motor driver



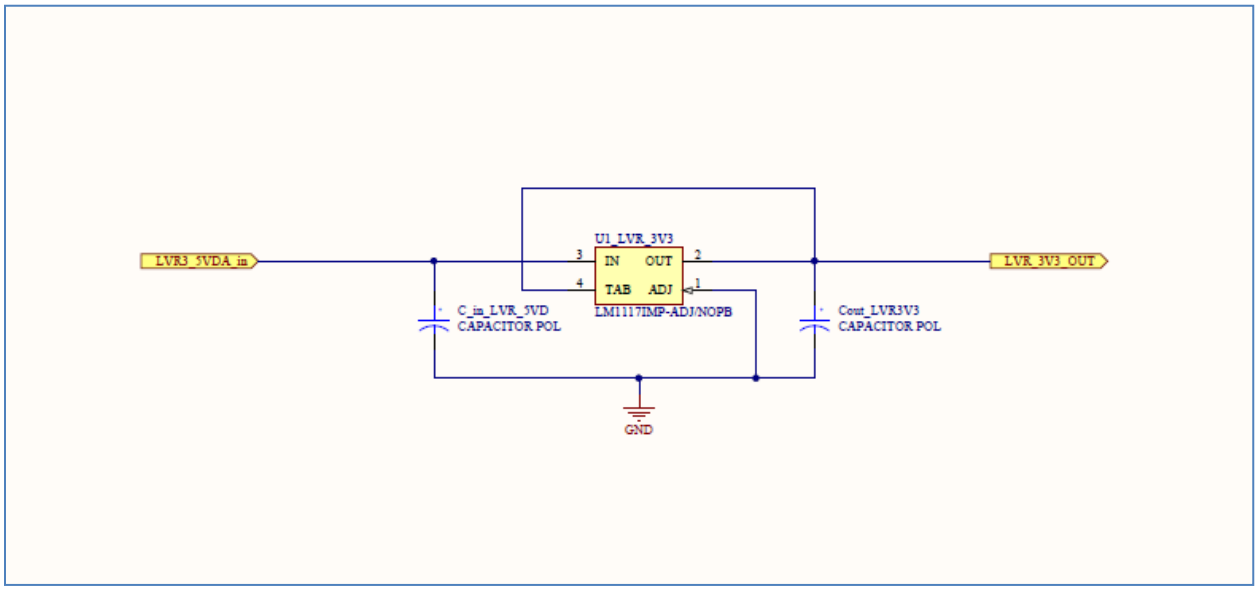
- Servo motor connections



- DC motor encoder

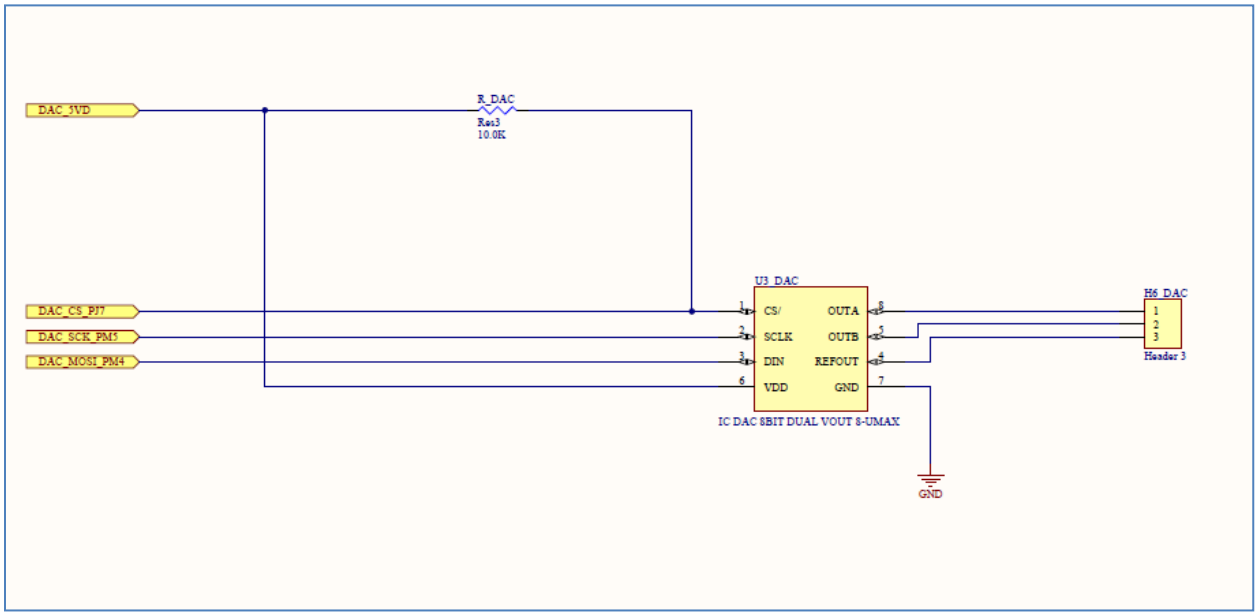


- Linear Voltage Regulator

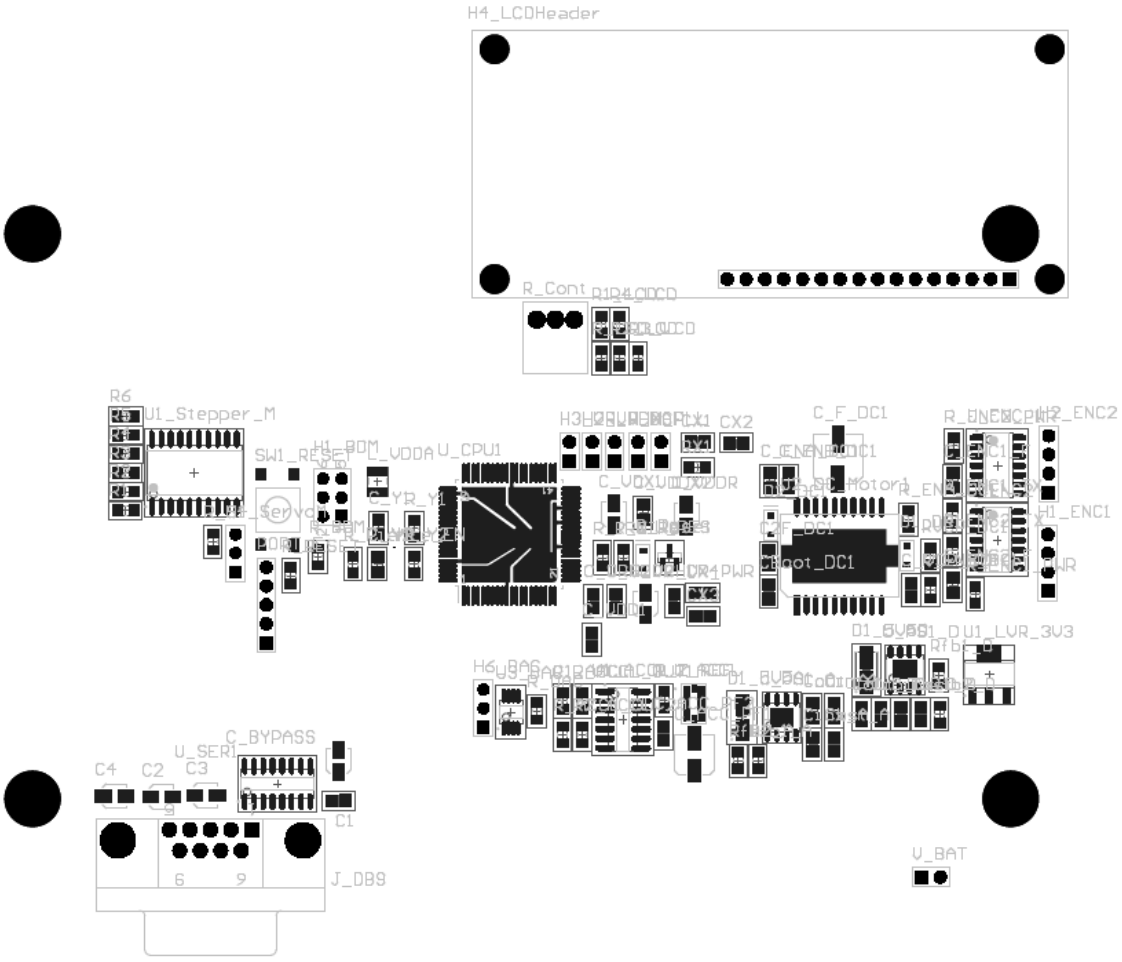


- Output = 3.3V powering accelerometer

- DAC



- PCB preliminary print out



- Connected to SCM12 through UART (MAX3232)
- Used for additional GPIO pins

5.2.6.Power requirements

- Power supplies requirements:
  - Two 5V SMPS and one linear 3.3V power supplies are required
- Main power connection driving the 5V power supplies and motors is 12V
- Maximum power consumption per chipset – TBD and tested (it varies on configuration)

5.3. Software Specifications

5.3.1. Programming environment

- The programming development environment for the HSC12 will be Code Warrior suite (refer to document 11 in 3.2 Documents List for software documentation)
- Other software specifications TBD

6. Chapter IV – Regulatory Requirements

6.1. Purpose:

The purpose of this chapter is track regulatory requirements that shall be kept during the design phase.

6.2. ESD Requirements

- Design for LM22675 require to comply with JEDEC document JEP155 500-V HBM
- Other requirements TBD

6.3. Soldering Requirements

- Refer to document 12 in 3.2 Documents List for National Semiconductor products soldering specs
- IPC standard that will be applied for this project – TBD

7. Reliability and Service

- The main reliability requirement is for the system to be able to run from 12V (current consumption is to be determined – dependent on configuration).