Carnegie Mellon University

16-681

MRSD Project I

Task 11 Power System Schematic
Team C - COBORG

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1. Brief Analysis

Table 1 - Critical Parts Analysis

Critical Part Name	P/N Used	Original Requirement	Requirement Modification (If Applicable)
Anderson Power Connectors	1317G11-BK, 1327-BK, & 1327G6-BK	Rated for 20A+	Rated for 45A
Power Path Controller	LTC4412HV	Switching functionality with an appropriate pFET.	
P-channel MOSFET	NVMFS5A140PLZWFT1G	Rated for 20A Source to Drain @ 40V	
5VDC Regulator	UWS-5/10-Q48NM-C	36VDC to 5VDC	91% efficiency
5V TVS	GSOT05C-HG3-08	Breakdown @ 10-30% overvoltage	Breakdown @ 6V (20% overvoltage)
19.5VDC Regulator	JRCS016A0S64-HZ	36VDC to 19.5VDC	95% efficiency, Variable output: 19.35V with a 33kΩ resistor
20V TVS	MMBZ24VALFHT116	Breakdown @ 10-30% overvoltage	Breakdown @ 22.8V (17% overvoltage)
36V TVS	GSOT36C-E3-08	Breakdown @ 10-30% overvoltage	Breakdown @ 39V (8.3% overvoltage)
Schottky Diode	VS-20TQ045-M3	DC Reverse >> 36V, Conducts up to 20A	DC Reverse @ 45V Max

In general, our selected parts were better than our set requirements. We had to use a variable regulator for the 19.5VDC output because 19.5VDC was not a standard regulator output voltage. We selected a pFET that could handle 20A and 40V to conduct the battery power supply for the power path controller. In order to protect the LTC4412HV power path controller, we connected a TVS with a breakdown voltage of 39V to the input battery power connector. For overvoltage safety, we also added the same TVS at the input of the external power connector and added appropriately rated TVSs to the output voltages of the regulators. The schottky diode was added to prevent current from flowing back into the external power port when the battery power was enabled. This is accomplished by the pFET for reverse current to the battery power port. We removed the concept of having an LED signify which power source the backpack was presently drawing from because the implementation was much less trivial than originally thought and it was deemed unnecessary. We do have LED indicators at both input power supplies and at the outputs of each of the regulators. We did not add any “e-stop” switches to cut the power on the board because we already have an e-stop between the power supply and the motors, and an e-stop that kills the power to the backpack overall. These e-stops are external to the PCB.

2. Efficiency and Heat Analysis

Below, in *Table 2*, we detail the efficiency and heat dissipation strategy for the PCB components we are including. By reading the component's datasheet we were able to accurately calculate the efficiency and heat output of each device. We are looking into active cooling for the computer's DC-DC converter as it is a 180W component. All the other components will be passively cooled by using adequate space and including airflow considerations in the PCB enclosure:

Table 2 - Efficiency and Heat Analysis

Part Name	**Output Voltage (V)**	**Nominal Current (A)**	**Peak Current (A)**	**Efficiency (%)**	**Heat Generated**	**Heat Dissipation Calculation and Strategy**
DC-DC Buck and Boost Power Converter JRCS016 A0S64-HZ	19.3	9.32	9.32	95	9.47 W	Heatsink + Active Fan. This is per manufacturer recommendation.
P-channel MOSFET NVMFS5A140PLZ	36V	6.12	9.94	-	293.5°C	(Tj-Tc)/0.75=358W, Tc = 25°C Tj =293.5°C This exceeds the 175°C Tj limit for this device and will require a heatsink to dissipate the excess heat generated from a potential peak power load.
5VDC Regulator UWS-5/10-Q48NM-C	5V	3A	5A	88%	2 W	Passive Convection. Heat generated will not exceed 120°C limit at ambient temperature.
Schottky Diode VS-20TQ045-M3	36V	10A	20A	-	204.5°C	(Tj-Tc)/0.50=358W, Tc = 25°C Tj =204.5°C This exceeds the 150°C Tj limit for this device and will require a heatsink to dissipate the excess heat generated from a potential peak power load.

Figure 1 - JRCS016 Efficiency Curve

Characteristic Curves

The following figures provide typical characteristics for the JRCS011

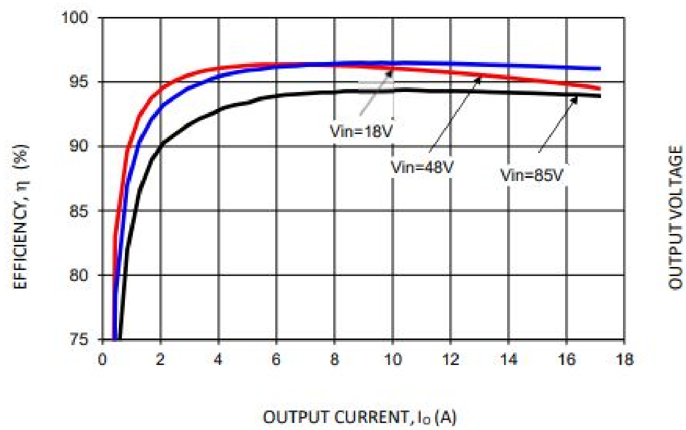

Figure 2 - NVMFS5A140PLZ Thermal Characteristics

THERMAL CHARACTERISTICS

See detailed ordering and shipping information on page 7 of this data sheet.

Symbol	Parameter	Value	Unit
$R_{\theta JC}$	Junction to Case Steady State	0.75	°C/W
$R_{\theta JA}$	Junction to Ambient Steady State (Note 2)	39	

1. The entire application environment impacts the thermal resistance values shown, they are not constants and are only valid for the particular conditions noted.
2. Surface mounted on FR4 board using a 650 mm^2, 2 oz. Cu pad.
3. Maximum current for pulses as long as 1 second is higher but is dependent on pulse duration and duty cycle.

Figure 3 - VS-20TQ045-M3 Thermal Characteristics

THERMAL - MECHANICAL SPECIFICATIONS					
PARAMETER		**SYMBOL**	**TEST CONDITIONS**	**VALUES**	**UNITS**
Maximum junction and storage temperature range		T_J, T_{Stg}		-55 to +150	°C
Maximum thermal resistance, junction to case		R_{thJC}	DC operation See fig. 4	1.50	°C/W
Typical thermal resistance, case to heatsink		R_{thCS}	Mounting surface, smooth, and greased	0.50	
Approximate weight				2	g
				0.07	oz.
Mounting torque	minimum			6 (5)	kgf · cm (lbf · in)
	maximum			12 (10)	
Marking device			Case style 2L TO-220AC	20TQ035	
				20TQ040	
				20TQ045	