Revisions			
Rev	Date	Description	Approved
A	12/31/2008		

STRESS AND DERATING ANALYSIS

Modular Platform

12V Converter

PREPARED BY

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December 31, 2008

SOW NO.	PREPARED BY CHARLES HYMOWITZ		DATE 12-31-2008
CONTRACT NO.	**APPROVALS**		**DATE**
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: .X ±.03 .XX ±.01 XXX ±.005 .XXXX ±.002 X° ±1° BREAK EDGES .005/.020 FILLET RADIUS .005/.020 SURFACE ROUGHNESS - 64 RMS INTERPRET PER SRC DRM.	AUTHORS	SS/PH	12/31/2008
	REVIEW	CEH	12/31/2008

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RESTRICTIONS ON USE OF THE REPORT

SDRL 0001	Size **A**	Date **31-Dec-08**	DWG NO **12V Converter**	REV
	Scale **N/A**	Cage code		

1.0 Stress/Derating Analysis

1.1 Scope

This document contains the nominal and worst case stress and derating analysis results for the 12V DC-DC Converter Module. The nominal and worst case (WC) circuit performance values are compared to recommended deratings to investigate whether components are used within their operational limits and that no overstress conditions exist.

Analysis:	**Stress & Derating Analysis**
Performed by:	**SS, DF, PH, DC**
Last Rev Date:	**6/16/2011**
Assembly:	**12V Converter Module**
Schematics:	Converter Schematic.pdf
Excel Files:	I Worst Case Stress.xls
Other Files:	stress calculations.mcd stress calculations.pdf BOM with Component Manufacturer info.xls

1.2 Applicable Documents

1. Mil-Handbook-1547 - Electronic Parts, Materials, And Processes For Space And Launch Vehicles, 06 July 1998
2. Mil-Std-975M - NASA Standard Electrical, Electronic, And Electromechanical (EEE) Parts List, 5 August 1994
3. Electronic Derating for Optimum Performance – Reliability Analysis Center, 15-11, 2000
4. Mil-Handbook-217 FN2 - Military Handbook Reliability Prediction Of Electronic Equipment, 28 February 1995

1.3 Method of Analysis

The voltage, current, and power levels, where appropriate for each specific device, were calculated for each of the electrical components in the converter. These levels were then compared to the derated values as per Mil-Hdbk-1547. If derated values were not provided in Mil-Hdbk-1547, Mil-Std-975M or Electronic Derating for Optimum Performance were used.

The stress & derating analysis is performed in order to examine whether all parts used in the system are well suited for their intended use. The analysis is accomplished by comparing the calculated stresses and stress ratios of the device's voltage, current, and power against established derating guidelines. This report calculates the nominal stress values under nominal conditions and the worst case stress under the worst operating (input/output) and environmental conditions.

The setup and function for the stress excel file is described in the following:

> The excel file for the stress analysis consists of one main stress sheet, one "Application Data" sheet, and one "Deratings" sheet. On the stress sheet, every component has its own internal part number and reference designator as shown below. The key nominal, worst case and rated/derated quantities for each unique part number are linked to the Deratings sheet. If any changes are made in the Deratings sheet, the rated/derated ratio numbers are automatically updated. The Application Data sheet contains results for other part characteristics not listed on the main stress sheet such as capacitor ripple current or FET gate voltage.

Ref Des	Part Type	Description	Value	**Nominal Voltage**	**Worst Case Voltage**	Rated Voltage	Nominal Derated Voltage	Worst Case Derated Voltage	(Rated) Nominal Voltage Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Voltage Stress Ratio	Worst Case Derated Stress Ratio
C10	GRM155F50J105ZE01D	CAP CER 1U-6.3V-Z-0402-TR-Y5V		5.00	5.20	6.30	3.15	4.41	0.794	0.825	1.587	1.179
C11	0402ZD104KAT2A	CAP CER 0.10U 10V 10% 0402 X5R		5.00	5.20	10.00	5.00	7.00	0.500	0.520	1.000	0.743
C12	0402ZD104KAT2A	CAP CER 0.10U 10V 10% 0402 X5R		5.00	5.20	10.00	5.00	7.00	0.500	0.520	1.000	0.743
C13	0402ZD104KAT2A	CAP CER 0.10U 10V 10% 0402 X5R		5.00	5.20	10.00	5.00	7.00	0.500	0.520	1.000	0.743
R1	ERJ1TRQJ2R2U_R1	RES-TF- 1W- 2.2 -J-2512N	2.2	1.10	1.10	200.00	160.00	160.00	0.006	0.006	0.007	0.007
R10	RK73H1ETTP4751F	RES 4K75 1% 50V 0.063W 0402 mf	4750	5.00	5.20	50.00	40.00	40.00	0.100	0.104	0.125	0.130
R100	RK73H1ETTP6982F	RES 69K8 1% 50V 0.063W 0402 mf	69800	24.49	25.49	50.00	40.00	40.00	0.490	0.510	0.612	0.637
R101	NRC04F1002TRF	RES MF 10.0K 1% .063W 0402	10000	0.00	5.20	50.00	40.00	40.00	0.000	0.104	0.000	0.130
R104	RK73B2BTTD121J	RES 120R 5% 200V 0.250W 1206 mf	120	1.11	1.23	200.00	160.00	160.00	0.006	0.006	0.007	0.008

Note: V-voltage, I-current, P-power.

In order to determine the stress ratio, the nominal (Nom) and worst case (WC) voltage/current/power for each component in the circuit are computed based on the operating conditions. Nom/WC stress ratio is equal to Nom/WC derated V/I/P divided by Nom/WC V/I/P. If stress ratio is larger than 1, then the part is considered to be overstressed and flagged in the left most columns. The stress number will be highlighted in purple if the ratio is between 0.85 – 1 which may be of concern. The stress number will be highlighted in RED if the ratio is larger than 1 (i.e. an overstressed part based on the DERATED quantity versus what the part actually sees in operation.

Ref Des	Part Type	Description	**Nominal Tboard**	**Nominal Temperature**	**WC Tboard**	**WC Temperature**
D31	MBRS360T3G	DIO-MBRS360-SCHTTY-3A-SM	25.00	81.20	67.00	105.20
K1	EC2-5NJ	RELAY-DPDT-5V 178OHM-2C	25.00	42.50	67.00	76.90
K2	EC2-5NJ	RELAY-DPDT-5V 178OHM-2C	25.00	41.50	67.00	76.90
K3	EC2-5NJ	RELAY-DPDT-5V 178OHM-2C	25.00	41.40	67.00	76.90

The Nom/WC temperatures are also included on the stress sheet since temperature can affect the stress results. The nominal temperature for each part is assumed to be the board temperature. The WC temperature is based on the board temperature. The temperature values are used in deratings sheet to determine the derating percentage for either cliff or linear deratings. The case and junction temperatures are also compared with the rated/derated temperature values for the part.

Capacitor Part Numbers	Rated Voltage	Nominal Voltage Derating	Worst Case Voltage Derating	Nominal Derated Voltage	Worst Case Derated Voltage	Rated Current	Nominal Current Derating	Worst Case Current Derating	Nominal Derated Current	Worst Case Derated Current	Rated Power	Nominal power Derating	Worst Case power Derating	Nominal Derated power	Worst Case Derated power	Resistance	WC Temperature	Nominal Temperature	Mil-spec	Max Nom Junction Temp	Max WC Junction Temp	Note
EMV-160ADA100MD55G	16	80%	0%	12.8	0												67	25	EDOP			Aluminum
GRM155F50J105ZE01D	6.3	50%	70%	3.15	4.41												67	25	1547			Chip, Ceramic
04025A6R8CAT2A	50	50%	70%	25	35												67	25	1547			Temp Compensat, Ceramic (CC,
Diode Part Numbers																						
LL4148	100	70%	70%	70	70	2	50%	50%	1	1	0.5	100%	100%	0.5	0.5		67	25	1547	105	105	Small Signal Fast Switching Diode,
BZD27C36P											0.8	50%	50%	0.4	0.4		67	25	1547	105	105	Zener, Ta = 25C
SM6T36A						100	75%	75%	75	75	600	75%	75%	450	450		67	25	1547	105	105	Clamping diode,
Transistor Part Numbers																						
BCP56T1G	80	70%	70%	56	56	1	75%	75%	0.75	0.75	1.5	50%	50%	0.75	0.75		90.6	55.3	1547	105	125	NPN Bipolar
DDTC114YCA-7-F	50	70%	70%	35	35	0.07	75%	75%	0.0525	0.0525	0.2	50%	50%	0.1	0.1		67	25	1547	105	125	Prebiased NPN Bipolar Transistor,
MOSFET Part Numbers																						
IRFR9024NCTRPBF	55	75%	75%	41.25	41.25	8	75%	75%	6	6	38	50%	50%	19	19		67	25	1547	105	125	P-channel FET
2N7002LT1G	60	75%	75%	45	45	0.8	75%	75%	0.6	0.6	0.225	50%	50%	0.1125	0.1125		67	25	1547	105	125	N-channel FET
Inductor Part Numbers																						
B82462G4472M						2	100%	100%	2	2							67	25				SMT Inductor
CDR74NP-101MC						0.52	100%	100%	0.52	0.52							67	25				SMD Inductor
B82464G4223M000						2.25	100%	100%	2.25	2.25							67	25				SMT Inductor

On the Deratings sheet, part numbers are listed. The rated voltage/current/power, found usually on the datasheet, are entered in the corresponding columns. If two parts that use the same part number have different temperatures that would affect the deratings, two separate deratings rows are used with an added suffix (the reference designator) to distinguish between the two parts.

The derated voltage/current/power is then computed based on the rated number and deratings percentage, i.e. Derated number = Derating % * Rated number. The nominal and WC temperatures are extracted from the stress sheet.

1.4 Nominal and Worst Case Stress Analysis Results

12V Converter Worst Case Stress.xls

Ref Des	Part Type	Description	Value	Nominal Voltage	Worst Case Voltage	Rated Voltage	Nominal Derated Voltage	Worst Case Derated Voltage	(Rated) Nominal Voltage Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Voltage Stress Ratio	Worst Case Derated Stress Ratio	Voltage Notes
C1	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		27.2	29.2	50.00	25.00	35.00	0.544	0.584	1.088	0.834	3
C10	04025C221KAT2A	CAP CER 220P 50V 10% 0402 X7R		40	43.2	50.00	25.00	35.00	0.800	0.864	1.600	1.234	56
C11	04025A470JAT2A	CAP CER 47P 50V 5% 0402 C0G		1	1.1	50.00	25.00	35.00	0.020	0.022	0.040	0.031	48
C12	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		3.712	3.961	50.00	25.00	35.00	0.074	0.079	0.148	0.113	43
C13	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		0.005	2.00E-02	50.00	25.00	35.00	0.000	0.000	0.000	0.001	31
C14	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		11	11.55	50.00	25.00	35.00	0.220	0.231	0.440	0.330	35
C15	GRM21BR71H474KA88L	CAP-CC- .47M- 50V-K-0805-X7R		11.3	12.5	50.00	25.00	35.00	0.226	0.250	0.452	0.357	40, From output
C16	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		27.1809	29.1809	50.00	25.00	35.00	0.544	0.584	1.087	0.834	15
C17	06035C103JAT2A	CAP CER 10N 50V 5% 0603 X7R		11.293	12.478	50.00	25.00	35.00	0.226	0.250	0.452	0.357	20
C18	06035C103JAT2A	CAP CER 10N 50V 5% 0603 X7R		10.09	10.298	50.00	25.00	35.00	0.202	0.206	0.404	0.294	23
C19	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		2.495	2.525	50.00	25.00	35.00	0.050	0.051	0.100	0.072	30
C2	GRM32ER71H475KA88L	CAP CER 4.7uF 50V 10% 1210 X7R		27.1809	29.1809	50.00	25.00	35.00	0.544	0.584	1.087	0.834	5
C20	C0402C103K5RAC	CAP CER 10000P 50V 10% 0402 X7R		2.5	2.525	50.00	25.00	35.00	0.050	0.051	0.100	0.072	25
C3	GRM32ER71H475KA88L	CAP CER 4.7uF 50V 10% 1210 X7R		28	30	50.00	25.00	35.00	0.560	0.600	1.120	0.857	54
C4	GRM31CR61E106KA12L	CAP CER 10U 25V 10% 1206 X5R		12.065	13.356	25.00	12.50	17.50	0.483	0.534	0.965	0.763	6
C5	GRM31CR61E106KA12L	CAP CER 10U 25V 10% 1206 X5R		12	13.2	25.00	12.50	17.50	0.480	0.528	0.960	0.754	8
C6	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		5	5.05	50.00	25.00	35.00	0.100	0.101	0.200	0.144	47
C7	04025C102KAT2A	CAP CER 1000P 50V 10% 0402 X7R		2.8	2.8	50.00	25.00	35.00	0.056	0.056	0.112	0.080	44
C8	UVR1J100MDD1TD	CAP-AL 10U-20-63V		27.2	29.2	63.00	50.40	0.00	0.432	0.463	0.540	#DIV/0!	3
C9	C0402C103K5RAC	CAP CER 10000P 50V 10% 0402 X7R		3.712	3.961	50.00	25.00	35.00	0.074	0.079	0.148	0.113	43
D1	SM4007 (ROHS COMP)	DIO-SM4007 -SI 1A 1KVSM		28	30	1000.00	700.00	700.00	0.028	0.030	0.040	0.043	2
D2	BYM13-60-E3/25	DIODE SCHOTTKEY BYM13-60		40	43.2	60.00	42.00	42.00	0.667	0.720	0.952	1.029	55
D3	BAV70	DIODE UNI BAV70 SOT23				70.00	49.00	49.00	0.000	0.000	0.000	0.000	Not used in reverse
D4	SMBJ28CA-13-F	PROTECT SMBJ28CA TVS 45.4V Bi											
D5	SMBJ28CA-13-F	PROTECT SMBJ28CA TVS 45.4V Bi											
D6	MMSZ4698T1G	DIODE ZEN MMSZ4698 SOD123 11V 5% 0.5W											
L3	DO1608C-103MLC	COIL-10UH-M-1.1A -SMT											
L4	DO1608C-103MLD	COIL-10UH-M-1.1A -SMT											
LED1	APHK1608SYC	LED-1608-ST-YL-CL-CL-SMT		0.995	1.095	5.00	5.00	5.00	0.199	0.219	0.199	0.219	26, Steady state
Q1	NTD3055L104G	FET N-CAN POWER NTD3055L104 369C-01		28	30	60.00	45.00	45.00	0.467	0.500	0.622	0.667	Input
Q2	BCX19LT1G	TRA-BCX19 -NPN-SI SM		28	30	45.00	31.50	31.50	0.622	0.667	0.889	0.952	Input
R1	2322 734 61009	RES 10E 1% 150V 0,125W 0805 MF	10	3.97E-02	0.11	150.00	120.00	120.00	0.000	0.001	0.000	0.001	49
R10	NRC04F1002TRF	RES MF 10.0K 1% .063W 0405	10000	17	19.55	50.00	40.00	40.00	0.340	0.391	0.425	0.489	34
R11	NRC04F1002TRF	RES MF 10.0K 1% .063W 0407	10000	0.020661157	0.049586777	50.00	40.00	40.00	0.000	0.001	0.001	0.001	19
R12	2322 734 61009	RES 10E 1% 150V 0,125W 0805 MF	10			150.00	120.00	120.00	0.000	0.000	0.000	0.000	57
R13	RK73H2BTTD1001F	RES 1K 1% 200V 0.250W 1206	1000	1	1.1	200.00	160.00	160.00	0.005	0.006	0.006	0.007	50
R14	RK73H1ETTP3922F	RES 39K2 1% 50V 0.063W 0402 mf	39200	2.488	2.737	50.00	40.00	40.00	0.050	0.055	0.062	0.068	42
R15	NRC04F1002TRF	RES MF 10.0K 1% .063W 0408	10000	0.020661157	0.049586777	50.00	40.00	40.00	0.000	0.001	0.001	0.001	19
R16	NRC04F1002TRF	RES MF 10.0K 1% .063W 0409	10000	0.753	0.832	50.00	40.00	40.00	0.015	0.017	0.019	0.021	21
R17	NRC04F4321TRF	RES MF 4.32K 1% .063W 0402	4320	0	2.592	50.00	40.00	40.00	0.000	0.052	0.000	0.065	27, Current Limit in WC
R18	NRC04F1002TRF	RES MF 10.0K 1% .063W 0406	10000	0.672	0.687	50.00	40.00	40.00	0.013	0.014	0.017	0.017	22
R19	MCR01MZSF2001	RES-CHIP 2K-1-0402-100-0.063	2000			50.00	40.00	40.00	0.000	0.000	0.000	0.000	No Steady State
R2	RK73B2BTTD100J	RES 10R 5% 200V 0.250W 1206 mf	10	6.00E-02	6.00E-02	200.00	160.00	160.00	0.000	0.000	0.000	0.000	52
R20	NRC04F1002TRF	RES MF 10.0K 1% .063W 0410	10000	0.0004	0.005	50.00	40.00	40.00	0.000	0.000	0.000	0.000	24
R21	NRC04F1002TRF	RES MF 10.0K 1% .063W 0411	10000	2.5	2.525	50.00	40.00	40.00	0.050	0.051	0.063	0.063	25
R22	RK73H1ETTP1001F	RES 1K0 1% 50V 0.063W 0402 mf	1000			50.00	40.00	40.00	0.000	0.000	0.000	0.000	14, No Steady
R23	2322 734 61009	RES 10E 1% 150V 0,125W 0805 MF	10	3.97E-02	0.11	150.00	120.00	120.00	0.000	0.001	0.000	0.001	49
R24	2322 734 61009	RES 10E 1% 150V 0,125W 0805 MF	10	3.97E-02	0.11	150.00	120.00	120.00	0.000	0.001	0.000	0.001	49
R25	NRC04F1002TRF	RES MF 10.0K 1% .063W 0412	10000	2.5	2.525	50.00	40.00	40.00	0.050	0.051	0.063	0.063	25
R26	RK73H1ETTP1503F	RES 150K 1% 50V 0.063W 0402 mf	150000	11.293	12.478	50.00	40.00	40.00	0.226	0.250	0.282	0.312	20
R27	RK73H1ETTP1503F	RES 150K 1% 50V 0.063W 0402 mf	150000	10.09	10.298	50.00	40.00	40.00	0.202	0.206	0.252	0.257	23
R28	RK73H1ETTP1001F	RES 1K0 1% 50V 0.063W 0402 mf	1000			50.00	40.00	40.00	0.000	0.000	0.000	0.000	29, Current Limit
R29	MCR01MZSF1742	RES 17K4-1-0402-100-0.063	17400	22.43093923	24.03314917	50.00	40.00	40.00	0.449	0.481	0.561	0.601	11
R3	NRC04F1003TRF	RES MF 100K 1% .063W 0402	100000	4.05	5.712	50.00	40.00	40.00	0.081	0.114	0.101	0.143	51
R30	NRC04F4321TRF	RES MF 4.32K 1% .063W 0402	4320	5.569060773	5.966850829	50.00	40.00	40.00	0.111	0.119	0.139	0.149	12
R31	CR10-1212-FT	RES 12K1 1% 50V 0.063W 0402 mf	12100	0.025	0.06	50.00	40.00	40.00	0.001	0.001	0.001	0.002	18
R32	2350 510 12107L	RES 0R1 1% 200V 250mW 1206	0.1	0.025	0.06	200.00	160.00	160.00	0.000	0.000	0.000	0.000	16
R33	RK73H1ETTP1R82F	RES 1R82 1% 50V 0.063W 0402 tf	1.82	0	0	50.00	40.00	40.00	0.000	0.000	0.000	0.000	9
R4	ERJ2RKF6651X	RES 6.65K 1% 50V 63mW 0402	6650	9.512	10.463	50.00	40.00	40.00	0.190	0.209	0.238	0.262	41
R5	NRC04F1821TRF	RES MF 1.82K 1% .063W 0402	1820	2.488	2.737	50.00	40.00	40.00	0.050	0.055	0.062	0.068	42
R6	NRC04F1002TRF	RES MF 10.0K 1% .063W 0402	10000	0.0004	0.005	50.00	40.00	40.00	0.000	0.000	0.000	0.000	17
R7	NRC04F1002TRF	RES MF 10.0K 1% .063W 0403	10000	0.0004	0.005	50.00	40.00	40.00	0.000	0.000	0.000	0.000	17
R8	RK73H1ETTP6811F	RES 6K81 1% 50V 0.063W 0402 mf	6810	3.8	3.85	50.00	40.00	40.00	0.076	0.077	0.095	0.096	45
R9	NRC04F1002TRF	RES MF 10.0K 1% .063W 0404	10000	5	5.05	50.00	40.00	40.00	0.100	0.101	0.125	0.126	46
T1	MSD1260-104MLD	IND FIX 100uH 20% 1,9A 0,161Ohm SMT											
U1	UC3843BD1R2G	IC(CURRMODEPWMCTRL) SM08		11.3	12.5	30.00	21.00	24.00	0.377	0.417	0.538	0.521	39, From output
U2	LM324MTX/NOPB	IC(LM324)QUAD OPAMP-SM		27.1809	29.1809	32.00	22.40	25.60	0.849	0.912	1.213	1.140	32
U3	NCP301LSN30T1G	IC(33464N-30)3V RST CRCT		5.569060773	5.966850829	12.00	8.40	9.60	0.464	0.497	0.663	0.622	13

Ref Des	Nominal Current	Worst Case Current	Rated Current	Nominal Case Derated Current	Worst Case Derated Current	(Rated) Nominal Current Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Current Stress Ratio	Worst Case Derated Stress Ratio	Current Notes	Nominal Power	Worst Case Power	Rated Power	Nominal Case Derated Power	Worst Case Derated Power	(Rated) Nominal Power Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Power Stress Ratio	Worst Case Derated Stress Ratio	Power Notes
C1																				
C10																				
C11																				
C12																				
C13																				
C14																				
C15																				
C16																				
C17																				
C18																				
C19																				
C2																				
C20																				
C3																				
C4																				
C5																				
C6																				
C7																				
C8																				
C9																				
D1	1.19E-01	3.30E-01	1.00E+00	5.00E-01	0.500	0.119	0.330	0.238	0.660	2										
D2	2.50E-01	1.50E+00	3.00E+01	1.50E+01	15.000	0.008	0.050	0.017	0.100	55, average current in nominal, peak										
D3	1.20E-02	1.70E-02	2.00E-01	1.00E-01	0.100	0.060	0.085	0.120	0.170	38										
D4	5.00E-06	5.00E-06	1.32E+01	9.90E+00	9.900	0.000	0.000	0.000	0.000	1	1.40E-04	1.50E-04	600.000	450.000	450.000	0.000	0.000	0.000	0.000	1
D5	0.00E+00	0.00E+00	1.32E+01	9.90E+00	9.900	0.000	0.000	0.000	0.000	10	0.00E+00	0.00E+00	600.000	450.000	450.000	0.000	0.000	0.000	0.000	10
D6											1.78E-02	2.17E-02	0.500	0.250	0.250	0.036	0.043	0.071	0.087	36
L3	2.50E-01	6.00E-01	1.20E+00	1.20E+00	1.200	0.208	0.500	0.208	0.500	7										
L4	1.19E-01	3.30E-01	1.20E+00	1.20E+00	1.200	0.099	0.275	0.099	0.275	4										
LED1	0.00E+00	6.00E-04	1.50E-01	1.13E-01	0.113	0.000	0.004	0.000	0.005	28, Current Limit in WC	0.00E+00	1.06E-03	0.125	0.063	0.063	0.000	0.008	0.000	0.017	28, Current Limit in WC
Q1	1.19E-01	1.70E-01	1.20E+01	9.00E+00	9.000	0.010	0.014	0.013	0.019	53	2.70E-02	3.80E-02	1.750	0.875	0.875	0.015	0.022	0.031	0.043	53
Q2	1.20E-02	1.70E-02	5.00E-01	3.75E-01	0.375	0.024	0.034	0.032	0.045	37	0.00E+00	3.44E-01	0.225	0.113	0.113	0.000	1.530	0.000	3.060	37,
R1											1.58E-04	1.21E-03	0.125	0.063	0.094	0.001	0.010	0.003	0.013	49
R10											2.89E-02	3.82E-02	0.063	0.031	0.047	0.462	0.612	0.925	0.815	34
R11											4.27E-08	2.46E-07	0.063	0.031	0.047	0.000	0.000	0.000	0.000	19
R12											9.30E-02	1.09E-01	0.125	0.063	0.094	0.744	0.872	1.488	1.163	57
R13											1.00E-03	1.21E-03	0.250	0.125	0.188	0.004	0.005	0.008	0.006	50
R14											1.58E-04	1.91E-04	0.063	0.031	0.047	0.003	0.003	0.005	0.004	42
R15											4.27E-08	2.46E-07	0.063	0.031	0.047	0.000	0.000	0.000	0.000	19
R16											5.67E-05	6.92E-05	0.063	0.031	0.047	0.001	0.001	0.002	0.001	21
R17											0.00E+00	1.50E-03	0.063	0.031	0.047	0.000	0.024	0.000	0.032	27, Current Limit in WC
R18											4.52E-05	4.72E-05	0.063	0.031	0.047	0.001	0.001	0.001	0.001	22
R19													0.063	0.031	0.047	0.000	0.000	0.000	0.000	
R2											3.60E-04	3.60E-04	0.250	0.125	0.188	0.001	0.001	0.003	0.002	52
R20											1.60E-11	2.50E-09	0.063	0.031	0.047	0.000	0.000	0.000	0.000	24
R21											6.25E-04	6.38E-04	0.063	0.031	0.047	0.010	0.010	0.020	0.014	25
R22													0.063	0.031	0.047	0.000	0.000	0.000	0.000	
R23											1.58E-04	1.21E-03	0.125	0.063	0.094	0.001	0.010	0.003	0.013	49
R24											1.58E-04	1.21E-03	0.125	0.063	0.094	0.001	0.010	0.003	0.013	49
R25											6.25E-04	6.38E-04	0.063	0.031	0.047	0.010	0.010	0.020	0.014	25
R26											8.50E-04	1.04E-03	0.063	0.031	0.047	0.014	0.017	0.027	0.022	20
R27											6.79E-04	7.07E-04	0.063	0.031	0.047	0.011	0.011	0.022	0.015	23
R28													0.063	0.031	0.047	0.000	0.000	0.000	0.000	29
R29											2.89E-02	3.32E-02	0.063	0.032	0.047	0.459	0.527	0.918	0.703	11
R3											1.64E-04	3.26E-04	0.063	0.031	0.047	0.003	0.005	0.005	0.007	51
R30											7.18E-03	8.24E-03	0.063	0.031	0.047	0.115	0.132	0.230	0.176	12
R31											5.17E-08	2.98E-07	0.063	0.031	0.047	0.000	0.000	0.000	0.000	18
R32											6.25E-03	3.60E-02	0.250	0.125	0.188	0.025	0.144	0.050	0.192	16
R33											0.00E+00	0.00E+00	0.063	0.031	0.047	0.000	0.000	0.000	0.000	9
R4											1.36E-02	1.65E-02	0.100	0.050	0.075	0.136	0.165	0.272	0.219	41
R5											3.40E-03	4.12E-03	0.063	0.031	0.047	0.054	0.066	0.109	0.088	42
R6											1.60E-11	2.50E-09	0.063	0.031	0.047	0.000	0.000	0.000	0.000	17
R7											1.60E-11	2.50E-09	0.063	0.031	0.047	0.000	0.000	0.000	0.000	17
R8											2.12E-03	2.18E-03	0.063	0.031	0.047	0.034	0.035	0.068	0.046	45
R9											2.50E-03	2.55E-03	0.063	0.031	0.047	0.040	0.041	0.080	0.054	46
T1	1.19E-01	3.30E-01	2.20E+00	2.20E+00	2.200	0.054	0.150	0.054	0.150	58										
U1																				
U2											1.63E-01	3.50E-01	0.800	0.600	0.680	0.204	0.438	0.272	0.515	33, Total Pd
U3																				

1.5 Summary List of Stress Failures

The following stress failures were found:

Ref Des	Part Type	Description	Value	**Nominal Voltage**	**Worst Case Voltage**	Rated Voltage	Nominal Derated Voltage	Worst Case Derated Voltage	(Rated) Nominal Voltage Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Voltage Stress Ratio	Worst Case Derated Stress Ratio	Voltage Notes
C1	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		27.2	29.2	50.00	25.00	35.00	0.544	0.584	1.088	0.834	3
C10	04025C221KAT2A	CAP CER 220P 50V 10% 0402 X7R		40	43.2	50.00	25.00	35.00	0.800	0.864	1.600	1.234	56
C16	06035C104KAT2A	CAP CER .1uF 50V 10% X7R 0603		27.1809	29.1809	50.00	25.00	35.00	0.544	0.584	1.087	0.834	15
C2	GRM32ER71H475KA88L	CAP CER 4.7uF 50V 10% 1210 X7R		27.1809	29.1809	50.00	25.00	35.00	0.544	0.584	1.087	0.834	5
C3	GRM32ER71H475KA88L	CAP CER 4.7uF 50V 10% 1210 X7R		28	30	50.00	25.00	35.00	0.560	0.600	1.120	0.857	54
C8	UVR1J100MDD1TD	CAP-AL 10U-20-63V		27.2	29.2	63.00	50.40	0.00	0.432	0.463	0.540	#DIV/0!	3
D2	BYM13-60-E3/25	DIODE SCHOTTKEY BYM13-60		40	43.2	60.00	42.00	42.00	0.667	0.720	0.952	1.029	55
Q2	BCX19LT1G	TRA-BCX19 -NPN-SI SM		28	30	45.00	31.50	31.50	0.622	0.667	0.889	0.952	Input
R12	2322 734 61009	RES 10E 1% 150V 0,125W 0805 MF	10			150.00	120.00	120.00	0.000	0.000	0.000	0.000	57
U2	LM324MTX/NOPB	IC(LM324)QUAD_OPAMP-SM		27.1809	29.1809	32.00	22.40	25.60	0.849	0.912	1.213	1.140	32

Ref Des	**Nominal Current**	**Worst Case Current**	Rated Current	Nominal Case Derated Current	Worst Case Derated Current	(Rated) Nominal Current Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Current Stress Ratio	Worst Case Derated Stress Ratio	Current Notes
C1										
C10										
C16										
C2										
C3										
C8										
D2	2.50E-01	1.50E+00	3.00E+01	1.50E+01	15.000	0.008	0.050	0.017	0.100	55, average current in nominal, peak
Q2	1.20E-02	1.70E-02	5.00E-01	3.75E-01	0.375	0.024	0.034	0.032	0.045	37
R12										
U2										

Ref Des	**Nominal Power**	**Worst Case Power**	Rated Power	Nominal Case Derated Power	Worst Case Derated Power	(Rated) Nominal Power Stress Ratio	(Rated) Worst Case Stress Ratio	Nominal Derated Power Stress Ratio	Worst Case Derated Stress Ratio	Power Notes
C1										
C10										
C16										
C2										
C3										
C8										
D2										
Q2	0.00E+00	3.44E-01	0.225	0.113	0.113	0.000	1.530	0.000	3.060	37,
R12	9.30E-02	1.09E-01	0.125	0.063	0.094	0.744	0.872	1.488	1.163	57
U2	1.63E-01	3.50E-01	0.800	0.600	0.680	0.204	0.438	0.272	0.515	33, Total Pd

C1: Fail the nominal derated voltage stress.

C10: Fail both the derated voltage stresses.

C16: Fail the nominal derated voltage stress.

C2: Fail the nominal derated voltage stress.

C3: Fail the nominal derated voltage stress.

C8: Fail the worst case derated voltage stress.

D2: Fail the worst case derated voltage stress.

Q2: Fail the RATED power stress.

R12: Fail both the derated power stresses.

U2: Fail both the derated voltage stresses.

1.6 Assumptions

The following assumptions were made in order to complete this analysis.

- The BOM provided multiple manufacturers and part numbers for some of the parts. The first manufacturer and part number were used to obtain the electrical ratings. It is extremely important that other potential manufacturer's data be reviewed to see if their ratings are different.
- Mil-Hdbk-1547 does not include derating guidelines for aluminum electrolytic capacitors. Derating guidelines from "Electronic Derating for Optimum Performance" published by the Reliability Information Analysis Center have been used for these capacitors.
- Mil-Hdbk-1547 does not include derating guidelines for LEDs. Derating guidelines from "Technical Requirements for Electronic Parts, Materials, and Processes Used in Space and Launch Vehicles" (TOR) published by The Aerospace Corporation have been used for LEDs. The document does not include derating guidelines for reverse voltage; a derating of 100% has been used.
- No current derating guidelines exist for inductors and transformers, 100% current deratings have been used.
- The power rating for the MOSFET Q1 is the worst case power rating when the MOSFET is mounted on the minimum pad size recommended.
- Thermal impedances have not been included. Therefore, junction temperature calculations have not been included.
- The temperatures of the components are assumed to be the board temperature; 25C nominal and 67C in the worst case.

The following assumptions are for the stress calculations which can also be found in the MathCAD sheet:

- Nominal input voltage 28V, maximum input voltage 30V, and minimum input voltage 18V from specifications.
- Nominal output voltage 12V, maximum output voltage 13.2V, and minimum output voltage 10.8V from specifications (+/-10%).

- Nominal output current 250mA from 0-500mA range given, maximum output current 600mA from circuit description: “600mA through R32 will trip current limit.”
- Nominal efficiency 90%, minimum efficiency 80% from “The module shall be greater than 80% efficient at full load. At light load the efficiency may be less but the module shall generate less than 2.0W waste heat.”
- Nominal duty cycle 30%, minimum duty cycle 26.5%, maximum duty cycle 42.3%.
- The rise and fall time of the drive signal from U1 is zero when calculating the losses of the MOSFET Q1.
- Turn off time for the MOSFET is an assumption based on data provided on the datasheet. The actual turn off time will be lower because of higher driver voltage and no external gate resistance on the application circuit.
- The input bias current to the opamps was neglected for most calculations in the current limit circuitry.

1.7 Deratings

Table 1.7-1: Component voltage, current, and power deratings used in the nominal and worst case stress & derating analysis. Data can be found in the derating sheet of the Worst Case Stress.xls file.

Capacitor Part Numbers	Rated Voltage	Nominal Voltage Derating	Worst Case Voltage Derating	Nominal Derated Voltage	Worst Case Derated Voltage	Rated Current	Nominal Current Derating	Worst Case Current Derating	Nominal Derated Current	Worst Case Derated Current	Rated Power	Nominal power Derating	Worst Case power Derating	Nominal Derated power	Worst Case Derated power	Resistance	WC Temperature	Nominal Temperature	Mil-spec	Max Nom Junction Temp	Max WC Junction Temp	Note
06035C104KAT2A	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
04025C221KAT2A	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
04025C102KAT2A	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
C0402C103K5RAC	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
GRM31CR61E106KA12L	25	50%	70%	12.5	17.5												67	25	1547			Chip, Ceramic (CDR)
GRM21BR71H474KA88L	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
GRM32ER71H475KA88L	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
06035C103JAT2A	50	50%	70%	25	35												67	25	1547			Chip, Ceramic (CDR)
04025A470JAT2A	50	50%	70%	25	35												67	25	1547			Temp Compensat, Ceramic (CC, CCR)
UVR1J100MDD1TD	63	80%	0%	50.4	0												67	25	1547			Lead Mount, Elec, Alum (CE), rated 85C
Diode Part Numbers																						
SM4007 (ROHS COMP)	1000	70%	70%	700	700	1	50%	50%	0.5	0.5							67	25	1547	105	105	Rectifier
BAV70	70	70%	70%	49	49	0.2	50%	50%	0.1	0.1							67	25	1547	105	105	Small Signal Diode
BYM13-60-E3/25	60	70%	70%	42	42	1	50%	50%	0.5	0.5							67	25	1547	105	105	Rectifier
SMBJ28CA-13-F						13.2	75%	75%	9.9	9.9	600	75%	75%	450	450		67	25	1547	105	105	Voltage Suppressor
MMSZ4698T1G											0.5	50%	50%	0.25	0.25		67	25	1547	105	105	Zener
APHK1608SYC	5	100%	100%	5	5	0.15	75%	75%	0.1125	0.1125	1.25E-01	50%	50%	0.0625	0.0625		67	25	TOR	105	105	LED, Ta = 25C
Transistor Part Numbers																						
BCX19LT1G	45	70%	70%	31.5	31.5	0.5	75%	75%	0.3750	0.375	0.225	50%	50%	0.1125	0.1125		67	25	1547	105	125	NPN BJT Transistor
MOSFET Part Numbers																						
NTD3055L104G	60	75%	75%	45	45	12	75%	75%	9.0000	9	48	50%	50%	24	24		67	25	1547	105	125	N-channel FET
Inductor Part Numbers																						
DO1608C-103MLC						1.2	100%	100%	1.2	1.2							67	25				Inductor
DO1608C-103MLD						1.2	100%	100%	1.2	1.2							67	25				Inductor
Transformer Part Numbers																						
MSD1260-104MLD						2.2	100%	100%	2.2	2.2							67	25				Transformer
Resistor Part Numbers																						
2322 734 61009	150	80%	80%	120	120						0.125	50%	75%	0.0625	0.0938	10	67	25	1547			Film (RL, RLR, RN, RNR, RM)
NRC04F1002TRF	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	10000	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73H2BTTD1001F	200	80%	80%	160	160						0.25	50%	75%	0.1250	0.1875	1000	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73H1ETTP3922F	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	3.92E+04	67	25	1547			Film (RL, RLR, RN, RNR, RM)
CR10-1212-FT	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	12100	67	25	1547			Film (RL, RLR, RN, RNR, RM)
MCR01MZSF2001	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	2000	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73B2BTTD100J	200	80%	80%	160	160						0.25	50%	75%	0.1250	0.1875	1.00E+01	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73H1ETTP1001F	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	1000	67	25	1547			Film (RL, RLR, RN, RNR, RM)
NRC04F1821TRF	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	1.82E+03	67	25	1547			Film (RL, RLR, RN, RNR, RM)
NRC04F1003TRF	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	1.00E+05	67	25	1547			Film (RL, RLR, RN, RNR, RM)
ERJ2RKF6651X	50	80%	80%	40	40						0.1	50%	75%	0.0500	0.0750	6650	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73H1ETTP1503F	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	1.50E+05	67	25	1547			Film (RL, RLR, RN, RNR, RM)
MCR01MZSF1742	50	80%	80%	40	40						0.063	50%	75%	0.0315	0.0473	1.74E+04	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73H1ETTP6811F	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	6.81E+03	67	25	1547			Film (RL, RLR, RN, RNR, RM)
2350 510 12107L	200	80%	80%	160	160						0.25	50%	75%	0.1250	0.1875	1.00E-01	67	25	1547			Film (RL, RLR, RN, RNR, RM)
NRC04F4321TRF	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	4.32E+03	67	25	1547			Film (RL, RLR, RN, RNR, RM)
RK73H1ETTP1R82F	50	80%	80%	40	40						0.0625	50%	75%	0.0313	0.0469	1.82E+00	67	25	1547			Film (RL, RLR, RN, RNR, RM)
Linear Device																						
UC3843BD1R2G	30	70%	80%	21	24	1	75%	85%	0.75	0.85	0.702	75%	85%	0.5265	0.5967		67	25	1547	105	125	Current Mode Controller
LM324MTX/NOPB	32	70%	80%	22.4	25.6						0.8	75%	85%	0.6000	0.6800		67	25	1547	105	125	Op Amp
NCP301LSN30T1G	12	70%	80%	8.4	9.6												67	25	1547	105	125	Voltage Detector

1.8 Conclusion

Both the nominal and worst case stress analyses were completed for the 12V Converter Module. This report contains the latest nominal stress results along with the worst case stress results.

In the process of the analysis, several stress failures were uncovered. Most of the stress failures are the result of the derating factors, and most are marginally over the derated stress. Q2 fails the power rating but only conducts during startup.

These failures, listed in Section 1.5, "Summary List of Stress Failures" should be examined closely.

The following conclusions have been made for this analysis:

- The manufacturer of aluminum electrolytic capacitor C8 has rated the part's maximum temperature as 85C. The document EDOP has a cliff derating for this part type at 65C. The maximum temperature of the board is 67C. Therefore, at any applied voltage, the part will always fail the derated voltage.
- The worst case power dissipation calculated for Q2 is for startup when the output voltage has not risen to provide power for U1. It fails the rated power; however, the power dissipation is brief because the output voltage rises in a matter of a few milliseconds. When current limit occurs, the output voltage drops and may not turn on its OR diode, causing Q2 and its OR diode to turn on. Current limit should not be sustained for long periods otherwise the transistor may be burned.
- There is no steady state stress on the damping resistor R33. However, AC or dynamic current can overstress the component.
- The BOM provided multiple manufacturers and part numbers for some of the parts. The first manufacturer and part number were used to obtain the electrical ratings. It is extremely important that other potential manufacturer's data be reviewed to see if their ratings are different.

Other Potential Concerns

Both AC and transient domain SPICE models were created for the 12V converter. Several simulations were performed to analyze potential stress and design issues relating to the circuitry based on the specification and ratings from the individual parts.

During the initial turn on, the output voltage can overshoot substantially, due to the lack of damping in the filter. This may be minimized, but the rise time of the input, though the 28V boost has a diode connected directly from its input to its output.

The output voltage loop does not include soft-start, and more importantly, does not include a fault-recovery soft-start.

The opamp supply voltage is dangerously close to its maximum Vcc rating in normal operation and exceeds it as a result of the undamped input filter.

The SEPIC coupling capacitor, C3, is also undamped. This may cause control loop issues, though it appears that the control loop bandwidth is very low.

R33 is used to damp the ringing from L3, C5, however, the spec allows up to 1000uF of external capacitance which will not be damped by R33. Additionally, the output capacitors, C4 and C5, are X5R. These capacitors have very substantial tolerances, as well as, a very significant DC Bias effect. It will be important to understand the DC Bias effect of the particular capacitors you have chosen.

The output transient suppressor, D5, is designed to be placed on a 28V bus. The working voltage and the clamping voltage are well above the rating of the output capacitors and also well above the rating of the output diode, D2.

There is insufficient information regarding parasitic elements to determine the ringing on D2. In the absence of ringing, the diode voltage is Vout + Vin which may exceed the rating of the diode. This is especially true in the recovery from an overload condition.

While there is currently no plan to perform WCCA on this module, we did want to point out some of the more obvious concerns. You may wish to do some testing to verify some of these concerns, especially given that many of them can result in catastrophic failures. The stability of this converter is poor even under the best of conditions. The large load current range, load capacitance range and undamped resonances greatly exacerbate the issues.