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Spacelabs, Inc.

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	(CATEGORY)



SR69-1057

CR 101821

FINAL REPORT

MODIFICATION OF DC-DC
CONVERTERS

CONTRACT NAS 9-7854

PREPARED FOR:

NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
R&D PROCUREMENT BRANCH
MANNED SPACECRAFT CENTER
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FEBRUARY 4, 1969

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SECTION 1

INTRODUCTION

The DC-DC converter modification program required by NASA involved the incorporation of current limiting resistors into existing delivered hardware.

The failure analysis portion of the program required failure analysis and repair of delivered hardware, manufacturing process and test procedure changes for impedance pneumograph, and electrocardiograph signal conditioners.

The DC-DC converter modification program consisted of:

- . Design Data Package
- . Modification of 5 DC-DC converters
- . Modification of 41 DC-DC converters

The ZPN signal conditioner failure analysis program consisted of:

- . Failure Analysis
- . Repair
- . Manufacturing Process Changes and Test Procedure Changes for Electrocardiograph Signal Conditioner and Impedance Pneumograph Signal Conditioner

The contract was awarded to Spacelabs, Inc. in March of 1968; the modification program was completed in December 1968; and the failure analysis program was completed in January 1969.

The report is divided into sections, each of which discusses one particular aspect of the program. The program chronology highlights program events and serves to provide a brief overall view of the program.

SECTION 2

PROGRAM CHRONOLOGY

The program chronology which follows is a narrative of the month-by-month progress of the program. The presentation has been limited to a brief discussion of the program highlights.

March 1968

The contract was awarded in March 1968. Immediately following award of the contract, preliminary design data package work was initiated with major emphasis on the required layout changes.

April 1968

In mid-April, the design data package was delivered to NASA for approval. Material procurement was initiated. By the end of April, purchase orders had been placed for all necessary parts and material. Eleven GFE DC-DC converters had been received at Spacelabs, Inc. and functional testing of these eleven units had been completed. The analytical analysis of short circuit output conditions on the modified DC-DC converter was initiated.

May 1968

The eleven DC-DC converters received and functionally tested were modified to incorporate the current limiting resistors. Five of the modified units had progressed as far as PDA testing. A CEI cleaning specification was submitted to NASA for approval. The analytical analysis of short circuit output conditions was continuing.

June 1968

The analytical analysis of short circuit output conditions was completed and delivered to NASA. Fifteen reworked converters were shipped to NASA.

July 1968

Five GFE DC-DC converters were received, reworked, tested, and shipped. Scheduled receipt of GFE equipment was now behind schedule by 25 units. A revised schedule of GFE DC-DC converter delivery was requested in order to establish a program completion schedule.

August 1968

Eleven GFE DC-DC converters were received at Spacelabs. On August 27th, ten DC-DC converters (S/N's 021-030) were reworked, processed through PDA testing and shipped to NASA.

September 1968

On September 20, 1968, five units were shipped. Two ZPN's were returned to Spacelabs for failure analysis and repair. Failure analysis was conducted and repair of units was held up pending receipt of signed contract from NASA. Corrective action incorporation was initiated and incorporation into current Contract NAS 9-7937 was made effective.

October 1968

A total of 47 GFE DC-DC converters was received at Spacelabs. Forty-two had been reworked and shipped to NASA, four units were received with damaged connectors, and one unit was received with intermittent -10 v output. Further rework was held up pending disposition from NASA of the damaged units.

November 1968

Disposition was received from NASA regarding the additional units. Rework was initiated on the four GFE units received with damaged connectors. The one GFE unit received with intermittent -10 vdc output was to be returned to NASA as received.

December 1968

Six DC-DC converters were processed and shipped to NASA. The one DC-DC and the two ZPN repairs were held pending receipt of signed contract modification.

January 1969

The required contract modification was received from NASA. Repair and test of the two ZPN's was concluded and they and the one intermittent -10 v output DC-DC converter were shipped to NASA.

SECTION 3

DC-DC CONVERTER MODIFICATION

Drawing No. 104848 (Appendix A) represents the physical layout of the design modification incorporated in Block I and Block II, DC-DC converters. This modification incorporates the 10 ohm 1/8 watt resistors in series with the +10 volt and -10 volt output leads.

The modification incorporated into the DC-DC converter resulted in performance changes as listed below.

1. Output Ground

All units were modified to Block I grounding and shielding requirements.

2. Output Voltage

Output voltage regulation increased from $\pm 10.0 \pm 0.1$ vdc to ± 10.0 v + 0.100, - 0.400 volts d. c. under load variation.

All other performance and mechanical requirements remained as originally specified.

PDA data sheets reflecting the parameter tolerance changes are included as Appendix B. The rework procedure and operation instruction sheet are also included in Appendix B.

An analysis of d. c. short circuited output conditions of the modified DC-DC converter is included as Appendix C. This analysis demonstrates, analytically, that the incorporated modification will not result in any converter component part being electrically or thermally overstressed due to a short circuit condition existing at the converter output. It additionally demonstrates that upon removal of the short circuit condition, the converter operation will return to normal.

Also included in Appendix C is a copy of the drawing list for the modified DC-DC converter.

SECTION 4

FAILURE ANALYSIS AND REPAIR

Two impedance pneumograph signal conditioners were returned to Spacelabs for failure analysis and repair. The two units were originally manufactured under Contract NAS 9-4022.

- . ZPN S/N 013, P/N 103080
- . ZPN S/N 009, P/N 104230

Evaluation of failure analysis results indicated incorporation of the following listed corrective action items:

Items A through D are applicable to the ZPN signal conditioner.

Items A, B, and D are applicable to the ECG signal conditioner.

Action Items A, B, and D were incorporated to the ECG in process procedure due to the similarity of the modules and the possibility of the same occurrence in the ECG.

A. Sleeving of Connector Leads

This was instituted as a precautionary measure to eliminate the possibility of shorting of connector leads to any other point within the module.

B. Module Potting Fixture - Modification

This item was incorporated to reduce the pressure exerted on the module connector during the potting operation.

C. PDA Test Procedure Modification - Electrode Isolation Test

The test was incorporated to provide for detection of presence and magnitude of any d. c. level which might be present between either electrode "A" or "B" and power common.

D. Receiving Inspection Procedure Potentiometers

This procedure was modified to increase potentiometer cycling requirements from two cycles to twenty cycles. One cycle to consist of cw rotation until occurrence of cw clutch actuation, and rotation ccw to ccw clutch actuation. During cycling, wiper action to be monitored for evidence of discontinuity.

S/N 013, P/N 103080

A. Problem Area

+ 8.0 vdc level present on electrode "B".

B. Analysis Results

Internal short circuit condition existing between regulated + 8.0 vdc line and electrode "B" lead.

C. Corrective Action

Noted under Items A, B, and C, Page 4-1.

S/N 009, P/N 104230

A. Problem Area

Dynamic output could not be established at required level.

B. Analysis Results

Defective gain potentiometer. Wiper breaking contact with resistive element.

C. Corrective Action

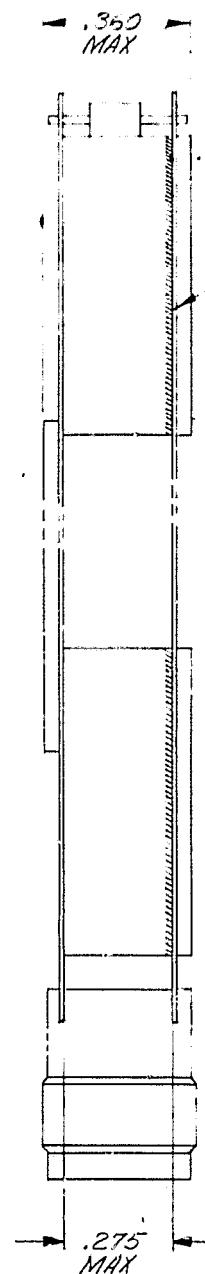
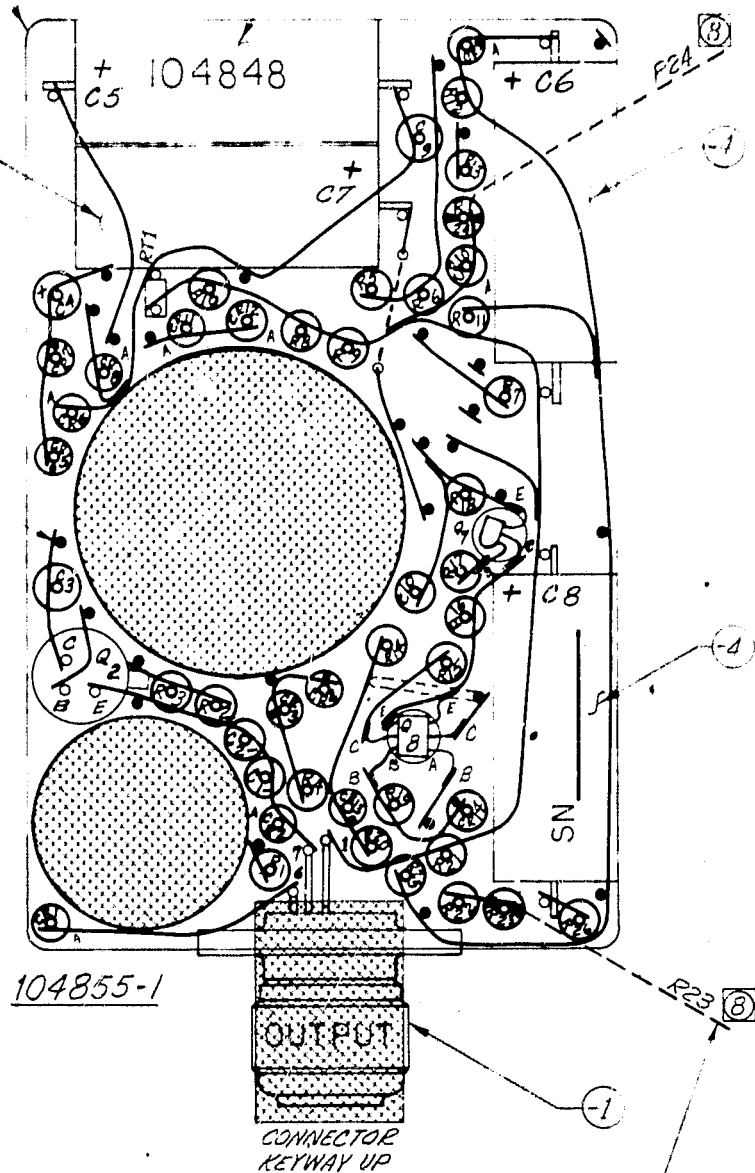
Noted under Item D, Page 4-2.

APPENDIX A

... WELD TO BE TRIMMED, WIRE
... FINAL TRIM LINES (TYP)

END STRAP
TO CASE

ALL FILED THRU'S TO BE
.020 DIA WIRE
(ITEM 32)



EPOXY CEMENT
ITEM 32 (TYP)

.007 X .007
RIBBON, IT
(TYP)

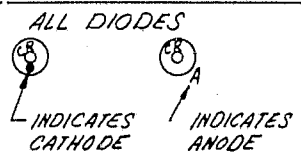
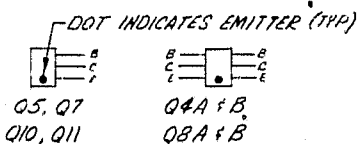
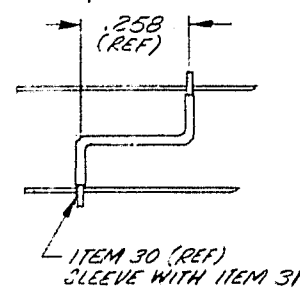
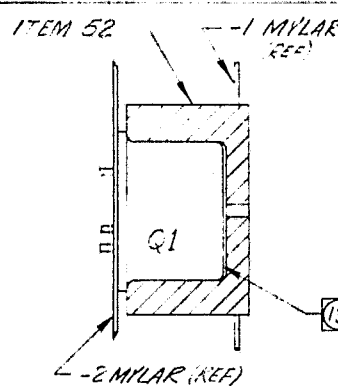
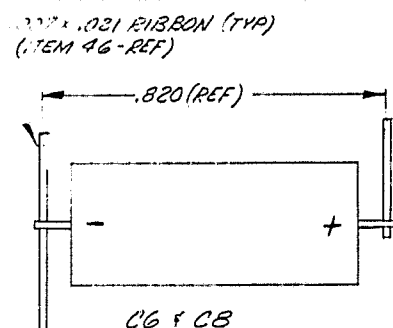
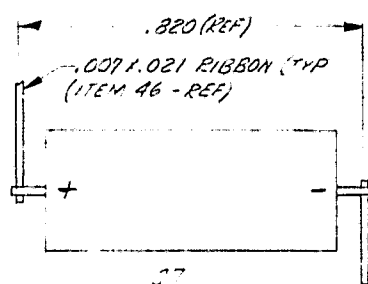
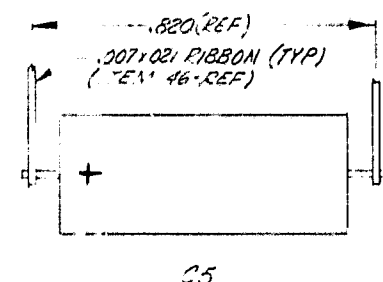
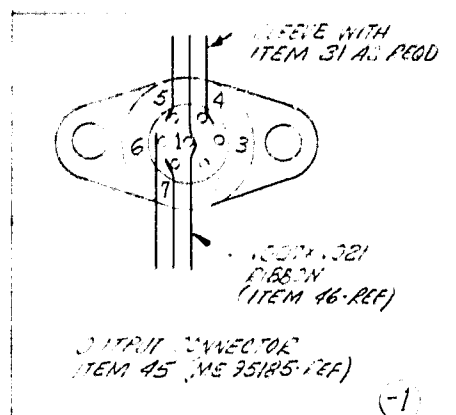
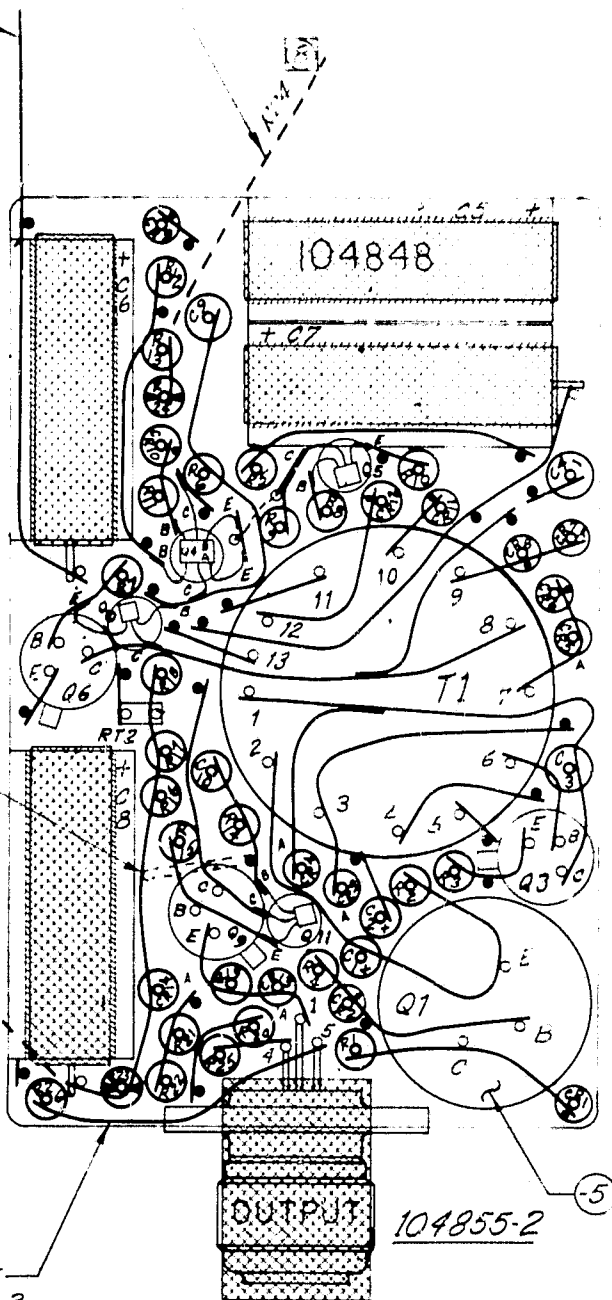
EXCESS RIBBON FOR SELECTION
OF R23 & R24 TO BE SLEEVED
WITH ITEM 31

13. APPLY ITEM 53 (DOW 340) BETWEEN Q1 & HEAT SINK
12. FOR TEMP. TEST PROCEDURE SEE 103457 & 104857
11. FOR SELECTION OF R23 & R24 REFER TO 103456
- 10.
9. AFTER ASSY, COAT WITH ITEM 34 (FREEZE COAT) PER 610001
8. AFTER SELECTION OF R23 & R24 CUT EXCESS RIBBON AS SHOWN.
7. RIBBON POSITIONS SHOWN FOR REFERENCE ONLY
6. FOR OUTLINE DWG. REFER TO 104840
5. FOR MASTER ARTWORK REFER TO 104855
4. FOR SCHEMATIC REFER TO 104842
3. FOR FINAL ASSY REFER TO 104843
2. FOR PARTS LIST REFER TO 104841
1. ALL WELDING TO CONFORM TO SPEC. 610101

NOTES: UNLESS OTHERWISE SPECIFIED

REVISIONS									
DISPOSITION	1 MAY BE REMOVED	2 CANNOT BE REMOVED	3 RECORD CHANGE						
CODE	4 NEW SHOP PRACTICE	5 PARTS MADE EX	6 RECORD CHANGE	DISP CODE	APPROVAL				
REV	WORD	DESCR PT. CH	MFG EFF	PART ASSY	DATE				
1		MODIFICATION REC ED 00767			1968 DJP				
2		REVISION REC ED 00767			1968 DJP				
3		REVISION REC ED 00767			1968 DJP				

EXCESS RIBBON FOR SELECTION
OF RESISTOR TO BE RECEIVED
WITH ITEM 31.



QTY PER ASSY	ITEM	PART NO	DESCRIPTION	MATL	MATL SPEC	ZONE	PART NO	EFF	MOD NO	REV	DATE
LIST OF MATERIAL											
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:											
.XX = ± .03 .XXX = ± .010 1" = ± .010 2" = ± .015											
WEIGHT IS IN LBS & TENTHS ALL FINISHED SURFACES 125/PER MIL STD 10											
MFR PER SPEC											
TOLERANCE SYMBOLS PER MIL STD 8 ELECTRICAL SYMBOLS PER MIL STD 18 MECHANICAL SYMBOLS PER MIL STD 12 WELDING SYMBOLS PER JAN STD 19											
DRAFT D. PAREN 8-8-68											
DESIGNER											
CHECKER											
MFG ENG											
BYOS ENG											
PROJ ENG											
TITLE											
COMPONENT PARTS ASSEMBLY, DC-DC CONVERTER											
APOLLO											
RELEASE DATE											
4:1											
WT ACT LB CALC LB SHEET 1 OF 1											
Spacelabs, Inc.											
104848											
REV B											

APPENDIX B

REV SYM	EQ NUMBER	DESCRIPTION	APPROVAL
1-1		PRODUCTION RELEASE PER E.O. 10385	198 NRP

DATA SHEET

APOLLO DC-DC CONVERTER

PART NO. 104840

SERIAL NO. _____ DC-DC Converter

TOTAL OPERATING TIME _____ Hours _____ Minutes (Converter)

SPACELABS Q.A. STAMP

GOVERNMENT Q.A. STAMP

PREPARED BY			Spacelabs, Inc.	
DESIGN.	<i>[Signature]</i>	<i>[Signature]</i>		
PROJ ENG			DWG NO	REV
QA ENG	<i>R Kaellw</i>	19 April 68	104845	<i>L/C</i>
NEXT ASSY		FINAL ASSY	Page 1 of 14	

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

SUMMARY OF OPERATION TIME

(a)	3.2.4.2	Burn-In Test	_____	hours	_____	minutes
(b)	3.2.5.2	Operating Time	_____	Minutes		
(c)	3.2.6.2	Operating Time	_____	Minutes		
(d)	3.2.7.2	Operating Time	_____	Minutes		
(e)	3.2.8.2	Operating Time	_____	Minutes		
(f)	3.2.9.3	Operating Time	_____	Minutes		
		Total Operating Time	_____	hours	_____	minutes

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

NOTE

The Data Sheets contained herein are the results of tests conducted in accordance with the Apollo DC-DC Converter, Acceptance Test Procedure, Drawing No.

104844. The results of each test shall be either "Accepted" or "Rejected" and the Spacelabs, Inc.

Q. A. Representative shall so indicate by affixing his stamp in the appropriate block. The Government

Q. A. stamp shall be entered adjacent to the Spacelabs

Q. A. stamp as applicable.

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

3.2.3 Examination of Product

3.2.3.1 Identification

a. DC-DC Converter Part No. 104840

Serial No. _____

Comments: _____

b. Nameplate

Accepted

Rejected

DC-DC Converter

Comments: _____

3.2.3.2 Size

a. DC-DC Converter

Accepted

Rejected

Length

Width

Height

Comments: _____

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

3.2.3.3.

Weight

a. DC-DC Converter

Weight

_____ grams

Accepted

Rejected

b. Weight Shall Not
Exceed 65 Grams

3.2.3.4

Connectors

a. DC-DC Converter

Accepted

Rejected

Output Connector

Comments: _____

3.2.3.5

Workmanship

a. DC-DC Converter

Accepted

Rejected

Workmanship

Comments: _____

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

3.2.3.6

Finish

a. DC-DC Converter

Accepted

Rejected

Finish

Comments: _____

3.2.3.7

Color Code

a. DC-DC Converter

Accepted

Rejected

Red Encapsulant

Comments: _____

Space Labs, Inc.

VAN NUYS, CALIFORNIA

3.2.4 Burn-In Test

3.2.4.1 Test Functions

(a) _____ vdc, Required: 16.8 ± 0.05 vdc.

(b) _____ vdc, Required: $+9.7 \pm 0.100$ vdc

(c) _____ vdc, Required: -9.7 ± 0.100 vdc

(d) Elapsed Time Meter Dial Reading _____

Date _____, 19____, Time of Day _____ A.M.
P.M.

(h) 16th through 32nd Hour of Operation

(b) _____ vdc, Required: 16.8 ± 0.05 vdc.

(d) _____ vdc, Required: $+9.7 \pm 0.100$ vdc

(c) _____ vdc, Required: -9.7 ± 0.100 vdc

(i) Elapsed Time Meter Dial Reading _____

Date _____, 19____, Time of Day _____ A.M.
P.M.

(l) After 50 Hr. Minimum Burn-In Time

(b) _____ vdc, Required: 16.8 ± 0.05 vdc.

(d) _____ vdc, Required: $+9.7 \pm 0.100$ vdc

(c) _____ vdc, Required: -9.7 ± 0.100 vdc

(n) Elapsed Time Meter Dial Reading _____

Date _____, 19____, Time of Day _____ A.M.
P.M.

(j) The time difference between the start and end of test shall be 50 hours minimum and all values above are within tolerances.

Accepted	Rejected
_____	_____

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3.2.4.2 (Continued)

TEST EQUIPMENT

+16.8 V DC (a) Power Supply, H/L 6233A, Serial No. _____, Cal. Date: _____
(b) Digital Voltmeter, HP 3420A, Serial No. _____, Cal. Date: _____

Total Operating Time: _____ Hours _____ Minutes

Q. A. STAMP _____

Space Labs, Inc.

VAN HUYB, CALIFORNIA

3.2.5 Input Voltage and Current and Output Regulation Test

3.2.5.1 Test Setup

3.2.5.2 Test Functions

Paragraph	Switch H/L Pos.	Input Voltage VOLTS	Input Current AMPS	+10V Output V TP3	-10V Output V TP5	OC Regulation Indicated Reqd.
(a)	2	16.81.05	.1A max.	10 ± 0.100		Indicated Reqd.
(b)	1	16.81.05	.1A max.	9.7 ± 0.100		Indicated Reqd.
(c)	2	20.81.05	.1A max.	10 ± 0.100		Indicated Reqd.
(d)	1	20.81.05	.1A max.	9.7 ± 0.100		Indicated Reqd.
(e)	2	14.81.05	.1A max.	10 ± 0.100		Indicated Reqd.
(f)	1	14.81.05	.1A max.	9.7 ± 0.100		Indicated Reqd.

Accepted Rejected

Above values within tolerances

O.A. STAMPS

TEST EQUIPMENT

416.8V (a) Power Supply, H/L 855 Serial No. Cal. Date:
(b) Ammeter, HP 412A, Serial No. Cal. Date:
(c) Digital Voltmeter, HP 3440A, Serial No. Cal. Date:

Total O.c. Lag Time Minutes

O.A. STAMPS

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

3.2.6 Short Circuit Current Test

3.2.6.1 Test Setup

3.2.6.2 Test Results

Paragraph	Switch SW Pos.	+10 V Current Test (mA)	-10 V Current Test (mA)	Input (TPD) Voltage (VOLTS)	QC Results
(a)	1	9.7 ± 0.100vdc	9.7 ± 0.100vdc	16.8 ± .05	Indicated Read
(b)	2	50 ma. max.	50 ± 0.1 VDC	16.8 ± .05	Indicated Read
(c)	3	9.7 ± 0.100vdc	50 ma. max.	16.8 ± .05	Indicated Read

Above values within tolerances

Accepted Rejected

Q.A. STAMP

TEST EQUIPMENT

+10.0V (a) Power Supply, H/L 855, Serial No. Cal. Date:
(b) Digital Voltmeter, HP 3420A, Serial No. Cal. Date:
(c) Ammeter, HP 412A, Serial No. Cal. Date:

Total Operating Time Minutes

Q.A. STAMP

Spacelabs, Inc.

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3.2.7 Reverse Polarity Test

3.2.7.1 Test Setup

3.2.7.2 Test Functioning

Paragraph	Input Voltage (VPI) (Volts)	+10 V Output Voltage (Volts)	-10 V Output Voltage (Volts)	Q.C.	Switch SW3 Position
(1)	20.8 $\pm$.05	9.7 $\pm$ 0.100	9.7 $\pm$ 0.100	Indicated Reqd.	NORMAL
(2)	20.8 $\pm$.05	0 $\pm$.01	0 $\pm$.01	Indicated Reqd.	REVERSE
(3)	20.8 $\pm$.05	9.7 $\pm$ 0.100	9.7 $\pm$ 0.100	Indicated Reqd.	NORMAL

Above values within tolerances

Accepted

Rejected

Q.A. STAMP

TEST EQUIPMENT

420.8 (a) Power Supply, H/L 865, Serial No. _____, Cal. Date: _____
(b) Digital Voltmeter, HP 3450A, Serial No. _____, Cal. Date: _____

Total Operating Time _____ Minutes

Q.A. STAMP

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

3.2.8 Power Common Isolation Test

3.2.8.1 Test Setup

3.2.8.2 Test Functions

Paragraph	Voltage (TP11-TP12)	Input Voltage (TP-1)	Q. C.
			Indicated
(e)	4.0 mv max.	40.0% .05 VDC	Required

Above values within tolerances

Q.A. STAMP

TEST EQUIPMENT

40 V DC (a) Power Supply, H/L 865, Serial No. _____, Cal. Date: _____
(b) Digital Voltmeter, HP 3440A, Serial No. _____, Cal. Date: _____

Total Operating Time _____ Minutes

Q.A. STAMP

VAN NUYS, CALIFORNIA

Spacelabs, Inc.

VAN NUYS, CALIFORNIA

3.2.9.3 Post Vibration Functional Test (performed as per 3.2.5)

Performed by _____

Date _____

Reference Paragraph	Switch SW1 Pos.	Input Voltage VOLTS	Input Current AMPS	+10v Output v TP3	-10v Output v TP5	QC Req'mts.
3.2.5.2 d	2					Indicated
		16.8 $\pm$ 0.05	0.1A max.	10 $\pm$ 0.100		Reqd.
e	1					Indicated
		16.8 $\pm$ 0.05	0.1A max.	9.7 $\pm$ 0.100		Reqd.
f	2					Indicated
		20.8 $\pm$ 0.05	0.1A max.	10 $\pm$ 0.100		Reqd.
g	1					Indicated
		20.8 $\pm$ 0.05	0.1A max.	9.7 $\pm$ 0.100		Reqd.
h	2					Indicated
		14.8 $\pm$ 0.05	0.1A max.	10 $\pm$ 0.100		Reqd.
i	1					Indicated
		14.8 $\pm$ 0.05	0.1A max.	9.7 $\pm$ 0.100		Reqd.

Above values within tolerances

Q.A. Stamp: Accepted _____ Rejected _____

TEST EQUIPMENT

+16.8v (a) Power Supply, H/L 865 _____, Serial No. _____ Cal. Date _____

(b) Ammeter, HP 412A, _____ Serial No. _____ Cal. Date _____

(c) Digital Voltmeter, HP 3440A, Serial No. _____ Cal. Date _____

Total Operating Time _____ Minutes

Q.A. Stamp _____

OPERATIONS SHEET & INSPECTION RECORD

N (103110) (104240)

DC-DC CONVERTER

MP-A 390 Rev. B

N S/N

REWORKED TO

CONTRACT NO. NAS7-7054

B

P/N 104340

S/N - Proj. Eng. C. Lombardi

TE

O. C. Buy off

Signature

A. REVIEW

Stamp

Date

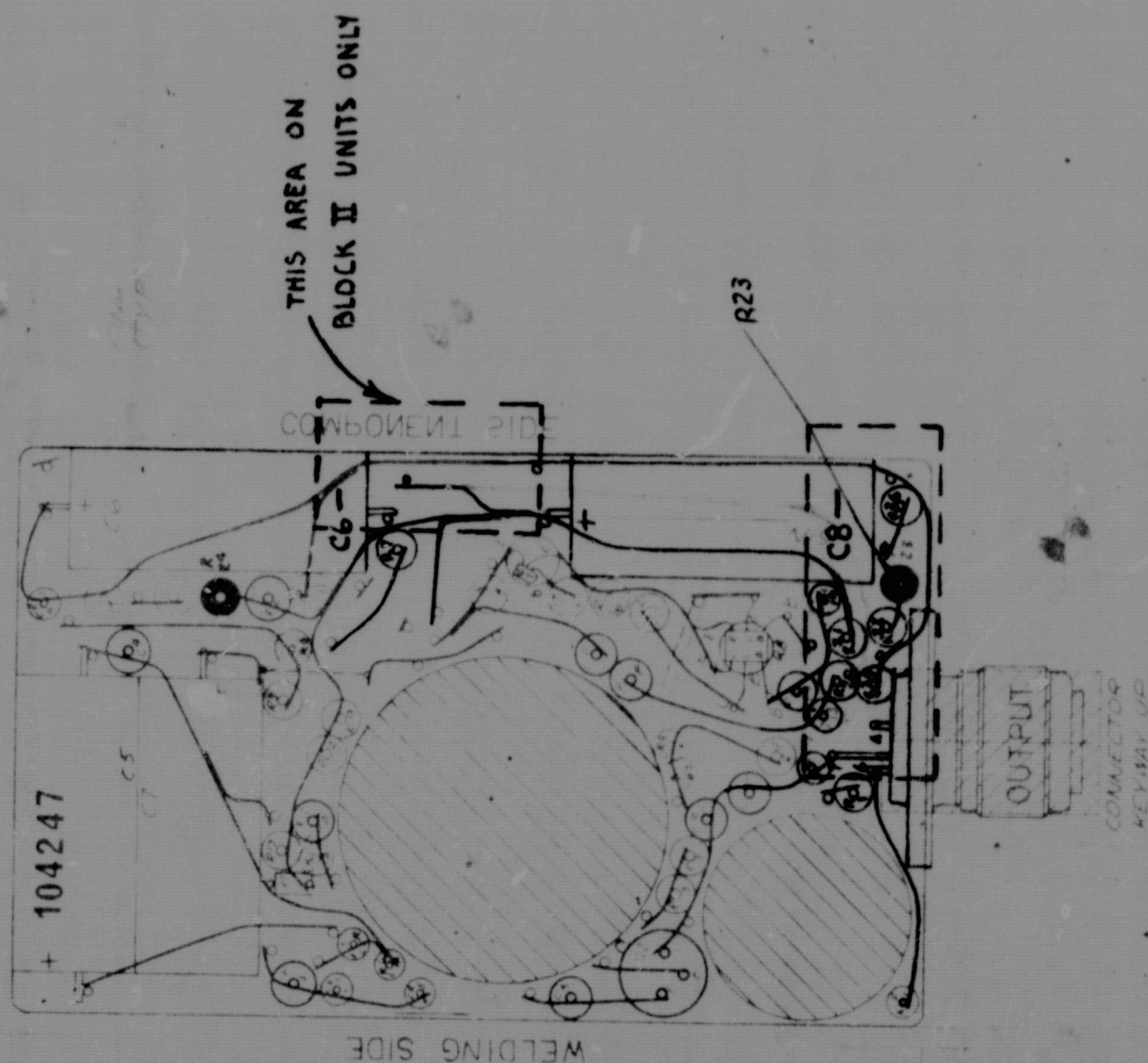
P. NO.	DESCRIPTION	Operator	Inspector	
			Accepted	Rejected
1.	<u>INCOMING INSPECTION :</u> a. Inspect each module in the shipping container for any evidence of damage sustained during transit. Any evidence of damage is cause for rejection. A rejection report (Spacelabs form SK7-101) will be made out immediately and submitted to the Quality Assurance Manager for review and customer notification. NOTE: Do not remove damaged units from the shipping package; Do not dispose of any of the packaging material. Secure all rejects in the MRE cabinet. b. If there is no evidence of shipping damage remove all packaging and examine each unit for the following: 1. Nameplate intact and serial number matches up with shipping documents. 2. Damage to case of connector. c. Check equipment logs received with units for correctness (serial number, NASA 772 entries, etc.) and enter a record of the incoming inspection. d. Make out a "GFP" label or tag for each unit and permanently attach it to the unit travel box. e. Record part number and serial no. of unit to be reworked along with job number and date in the upper left-hand corner of this operations sheet. f. Complete columns 1 thru 4 on the DC-DC Converter S/N control log sheet g. Route to test area for functional testing.	Time Date		
2.	a. Perform Acceptance Test per Dwg 103117 Rev paragraphs 3.2.5, 3.2.6, 3.2.7 and 3.2.8			

OPER. N°.	DESCRIPTION	Operator	Inspector	
			Accepted	Rejected
2. (cont)	Record all data as required on Data Sheet Dwg. No. 103113 (Block I) Rev. _____ or 104244 (Block II) Rev. _____ as applicable. b. Indicate accept or reject by placing QC stamp in the appropriate column for each test. c. Route unit and data sheets back to Receiving Area.	Date _____		
3.	Complete columns 5 and 6 of DC-DC Converter S/N control log. File data sheets with unit data package			
4.	Secure unit in Bonded Stores. Do not remove unit from tote box while in storage.	Date _____ By _____		
5.	Draw unit from Bonded Stores Issued By _____ Date _____			
6.	Remove case from potted electronics by using #620033 potted case removal adapter plate attached to Duemore miniature drill press with abrasive cutting disc. Cut 1/32" off each of 4 side case edges. Carefully pry up on case sides and remove case. Note: <u>Take extreme care not to damage connector threads while removing case.</u> Place teflon collar on connector and <u>leave on</u> to protect connector from damage. Remove top potting and potting from all sides of the electronics until the unit will fit a new case assem. P/N 102370-3. Use hot-knife for this operation. Ref: Spec. 610010 Rev. A.	Time _____ Date _____		
7.	A. Using a hot-knife, carefully remove epoxy in area of C6 negative end on cronaflex 104248-1. Cut ribbon 1/4" from feed-thru running to connector pin #3 and route to ribbon coming from C6 negative. Weld at this junction. Ref: Weld Sched. MPA 104 Rev. D Weld spec. 610101 Rev. A. Dwg 104848 B. Using a hot-knife, carefully remove epoxy on cronaflex 104248-1 from connector Pin #1 to edge	Time _____ Date _____		

OPER. No.	DESCRIPTION	Operator	Inspector	
			Accepted	Rejected
7. (cont.)	of electronics toward C8. The exposed area is not to go beyond R20 and R21. Remove Pin #3 and 3/8" of exposed ribbon going to it.			
8.	Using a hot-knife, carefully remove epoxy on cronaflex 104248-1 from connector Pin #4 to edge of electronics toward C8. The exposed area is not to go beyond R20 and R21. Cut ribbon going to Pin #4 at the connector pin; Carefully remove epoxy on cronaflex 104248-2 side, comparable to area on reverse side by the connector. Cut ribbon in the center of run between R20 and connector Pin #4; Remove ribbon below R23 to end of splice on ribbon going to connector Pin #5; Route ribbon coming from negative C8 to ribbon between CR14 and R23; using a No. 30 twist drill, drill holes (1) between R20 and connector and (1) below feed thru and negative end of C8; using a No. 55 twist drill, drill (1) hole for feed thru between negative end of C8 and R23 and drill (1) hole inboard between R21 and R22. Ref: Rework Spec 610010 Rev. A and Dwg. 104848.	Time _____ Date _____		
9. I. MSP.	O. C. inspect workmanship in O.P. #6 thru #8. List any rework on attached MPA 391 rework sheets. Note any damage to be corrected on any part of unit. Ref: Spec 610010 Rev. A and Dwg. 104848.	Time _____ Date _____		
10.	Install 10 $\sim$ resistor R25 below R20. Splice weld .007 x .015 nic. "A" ribbon to cut ribbon going to connector pin #4. Weld other end of ribbon to new R25. Install sleeved feed-thru of .020 dia nic. wire between R21 and R22. Splice weld .007 x .015 nic. "A" ribbon to cut ribbon from R20 and weld other end to feed-thru; weld ribbon routed to ribbon between CR14 and R23 from neg. C8. Install sleeved feed-thru of .020 dia. nic. wire below C8 and weld to ribbon routed to CR14 and R23. Install 10 $\sim$ resistor R26 between feed thru and neg end of C8. Weld .007 x .015 nic. "A" ribbon from added resistor R26 to cut ribbon coming from connector Pin #5. Splice weld new ribbon for case ground connection. Record Lot No's of mat'l used.	Time _____ Date _____		

OPER. NO.	DESCRIPTION	Operator	Inspector	
			Accepted	Rejected
10. (cont.)	R25 _____ R26 _____ .007 x .015 Nic. "A" Ribbon _____ .020 dia. nic. _____ wire _____ Ref: Weld spec. 610101 Rev. A Rework Spec 610010 Rev A Dwg. 104848, Weld sched MPA 104 Rev. D.			
I. INSP.	O. C. inspect workmanship and buy off of all welds in CP #11. Route acceptable units to test area. Ref; Weld spec. 610101	Time _____ Date _____		
T. INSP.				
12.	Functional test unit per para. 3.2.5, 3.2.6, and 3.2.7 of test proc. 104844	Time _____ Date _____		
I. INSP.				
13.	Clean unit in bath of genesolv-D. Dry thoroughly and apply light coat of WEMS-100 freezecoat to reworked areas only. Ref: Spec. 610001 Rev. A. Record Lot No and Exp. Date of WEMS-100 Lot No. _____ Exp. Date _____ Cure Date _____	Time _____ Date _____		
14.	O. C. inspection of CP #13 verify coating of freeze coat application by use of ultra-violet light. Reworked area to be free of all foreign material and completely covered with the freeze coat.	Time _____ Date _____		
I. INSP.				
15.	Apply light coat of E. C. epoxy #1090 SI to inside surfaces of new case and all sides of electronics. Insert electronics into case immediately. Add additional epoxy with hypodermic needle to insure complete encapsulation. Do not cover case ground ribbons and keep epoxy level 1/8" below top of potting case.			

PER. No.	DESCRIPTION	Operator	Inspector	
			Accepted	Rejected
15. (cont)	Ref: Spec 610006 Rev. B, and Dwg 104843. Record Lot No and Exp. Date of Stycast 1090 SI. Lot No. _____ Exp. Date _____ Cure Date _____	Time _____ Date _____		
16. I. INSP.	Functional Test unit per para. 3.2.5, 3.2.6 and 3.2.7 of test proc. 104844. Clip grd. ribbons together.	Time _____ Date _____		
17.	Weld ground ribbon to case ground ribbon. Ref: Weld spec. 610101 and weld sched. MPA 104 Rev. D. Dwg 104843	Time _____ Date _____		
18. I. INSP.	Q. C. Inspect Weld in CP #17. Ref: Weld spec 610101	Time _____ Date _____		
19.	Apply top-encapsulation of E. C. Stycast 1090 Epoxy color to match Ram color tint red #44-72. Ref: Dwg 104843 and spec 610006 Rev. B. Record Lot No and Exp Date of Stycast 1090 Lot No. _____ Exp. Date _____ Cure Date _____	Time _____ Date _____		
20. I. INSP. VT. INSP.	Perform acceptance test of unit per procedure 104844 and record data on data sheets 104845. Perform 50 hr. burn-in. NOTE: After final test route unit together with all paperwork to the receiving inspection area.	Time _____ Date _____		
21. I. INSP.	a. Complete columns 7 thru 9 of DC-DC Converter SN Control log. NOTE: Serial numbers will be assigned sequentially as units are recorded on the log beginning with 001 for the first unit to reach this point.	New S/N Assigned		



DC-DC Converter Modification

P/N104840

Weld Rework Sheet MP-A 391 Rev.

APPENDIX C

ANALYSIS OF SHORT-CIRCUITED
OUTPUT CONDITION
IN MODIFIED DC-DC CONVERTERS

CONTRACT NO. NAS 9-7854

PREPARED BY:

SPACELABS, INC.
14630 TITUS STREET
VAN NUYS, CALIFORNIA

JUNE 4, 1968

SCOPE

The object of this document is to show that the addition of two 10 ohm resistors in series with the positive and negative outputs of the DC-DC Converter, Spacelabs P/N 103110 and 104240, will not cause overstressing or overheating to any component in the equipment, upon application of a short to the converter output, and that all circuit parameters will return to normal operation upon removal of the short.

APPLICABLE DOCUMENTS

The following Spacelabs documents form a part of this document.

Drawing No. 103113 A, Schematic DC-DC Converter

Drawing No. 104243 N/C, Schematic DC-DC Converter
Block II Apollo

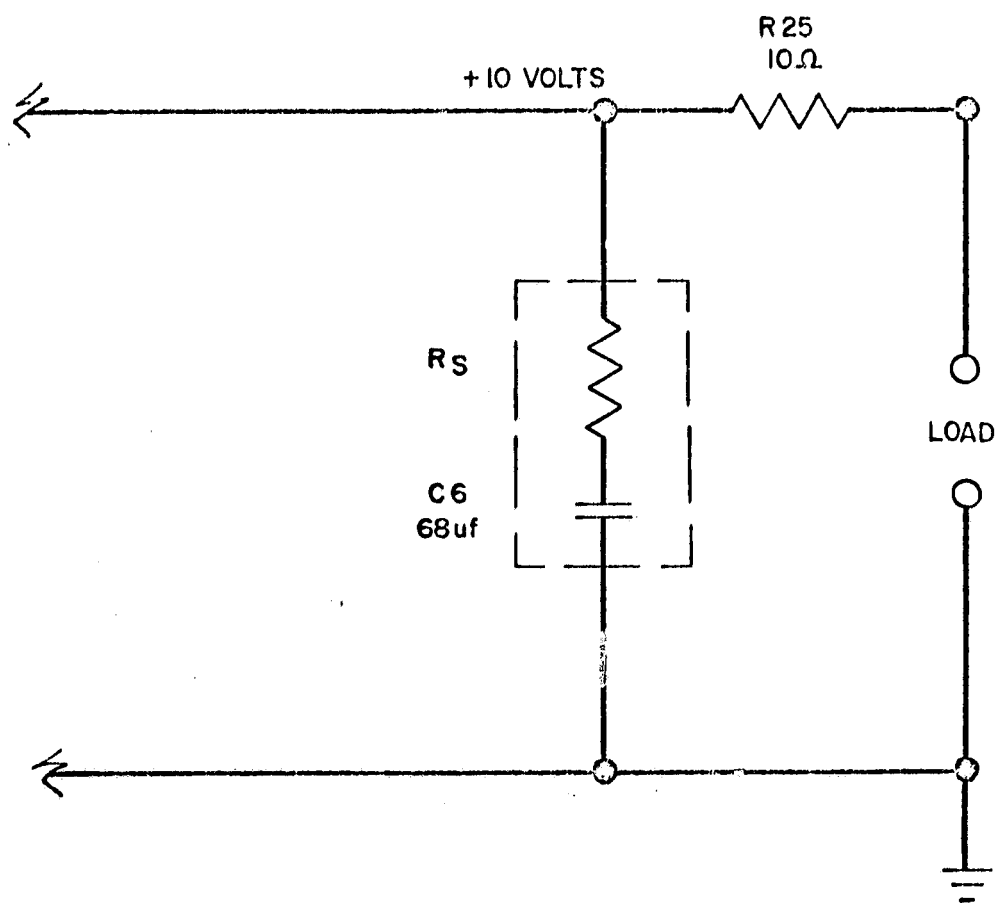
Drawing No. 104842 N/C, Schematic DC-DC Converter

PRELIMINARY NOTES

This document deals only with the electric aspect of the modification, that is, the addition of a 10 ohm, 1/8 watt resistor to both converters, P/N 103110 and P/N 104240, which are electrically identical. The only difference is the grounding configuration. The output voltage and current limiting specifications are the same.

TRANSIENT RESPONSE ANALYSIS

The modified positive output of Converter P/N 104240 will be used here as a sample for this analysis. The components of interest for the transient analysis are shown in Figure 1.



MODIFIED CONVERTER OUTPUT

FIGURE 1

Under normal operating conditions the capacitor is charged to +10 volts. When a short occurs between the converter output and ground C discharges to ground through R_s and R25, the value of the maximum instantaneous current is given by:

$$I = \frac{10v}{(10 + R_s) \text{ ohms}} \text{ amperes,}$$

where R_s is the internal capacitor resistance.

The value of R_s can be calculated for a sinusoidal, 120 H_z forcing function, from the manufacturer's data sheet. However, for a transient response, where the fast rise of the current pulse implies higher frequency components, R_s cannot be determined simply from the data sheets because of the change in C and R_s as the frequency increases. The worst case occurs when R_s is minimum which gives a maximum value of current. The manufacturer's data sheet gives a range of R_s values from 5 ohms to 0.3 ohms in the frequency range of 15 H_z to 30 KH_z.

Using 0.3 ohm for R_s as a worst case:

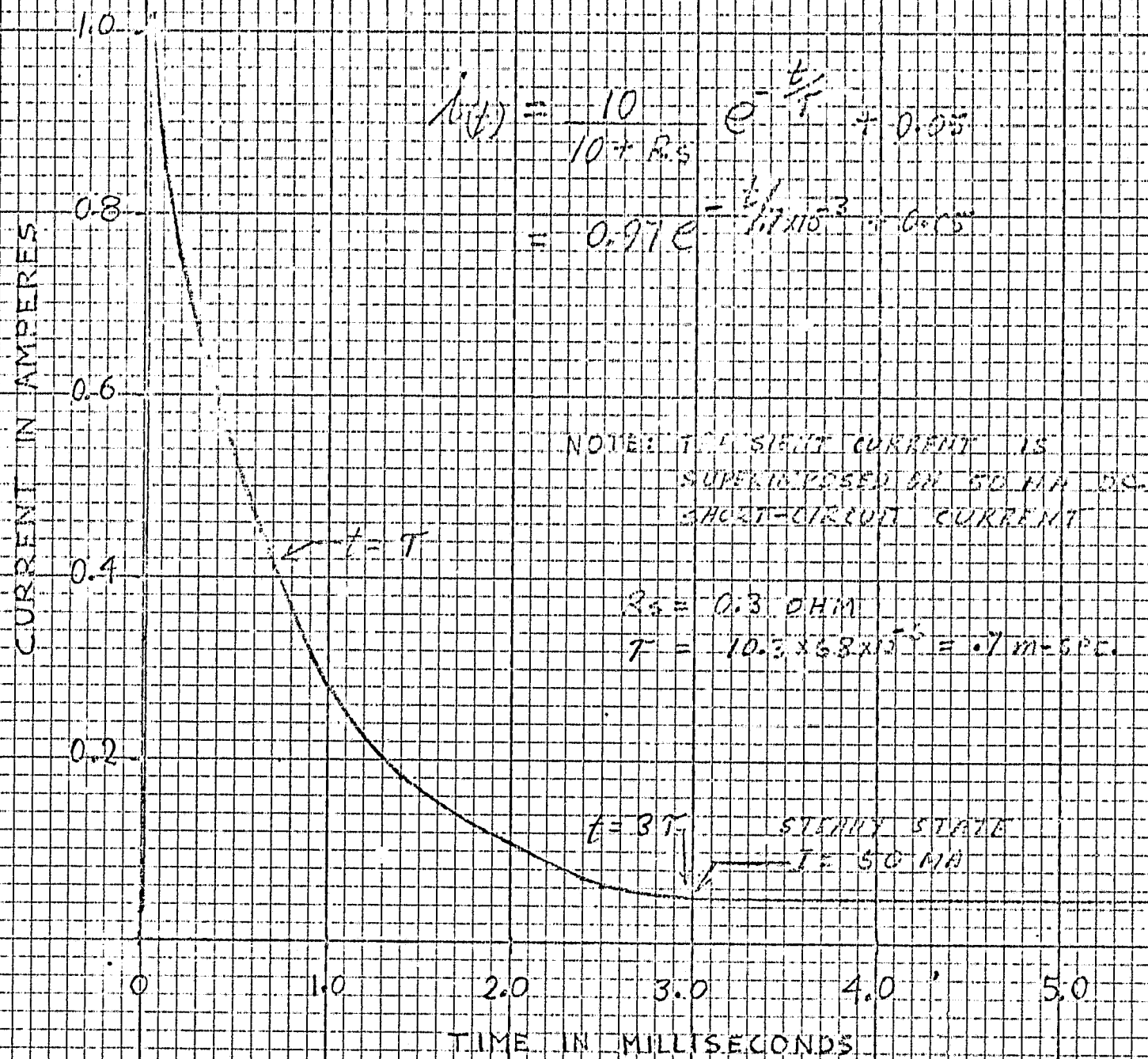
$$I_{\text{peak}} = \frac{10}{10 + 0.3} = 0.97 \text{ ampere}$$

The current pulse does not rise instantaneously to its peak value because of the inductance in series with R_s in the capacitor. This inductance, although small, will cause the leading edge of the pulse to have a finite rise time.

The value of the capacitor discharge current, as a function of time, is given by:

$$I(t) = \frac{10}{R25 + R_s} e^{-\frac{t}{\tau}} \text{ amperes}$$

where the time constant RC is given by $(R25 + R_s)C$ and is equal to 0.7 milliseconds. The discharge current is plotted in Figure 2. This plot gives the transient response plus the d.c. short circuit current. The instantaneous power dissipated in R25 when the current is at its peak value is:



SHORT CIRCUIT CURRENT RESPONSE

FIGURE 2

$$\begin{aligned}
 P &= I^2 R \\
 &= (0.97)^2 (10) \\
 &= 9.4 \text{ watts}
 \end{aligned}$$

However, the total energy dissipated in the 10 ohm resistor, neglecting the dissipation in R_s , is equal to the energy stored in the capacitor and is equal to:

$$\begin{aligned}
 W &= \frac{1}{2} C e^2 \\
 &= \frac{1}{2} (68 \times 10^{-6}) (100) \\
 &= 3.4 \times 10^{-3} \text{ joules}
 \end{aligned}$$

This amount of energy is insufficient to overheat or overstress the 10 ohm resistor.

During the transient response the surge current flows only through capacitor C8 and resistor R25 and no other component in the converter. The discharge of capacitor C8 cannot overstress this capacitor.

Therefore as a result of the transient response no component in the converter will be overstressed.

STEADY-STATE RESPONSE ANALYSIS

As shown in Figure 2, the current does not decay to zero because of the current supplied by the converter in the short circuit condition which is 50 ma. The addition of the 10 ohm resistor does not significantly change the limiting value of this current, which causes a voltage drop across the 10 ohm resistor of 500 millivolts.

The short circuit current flows essentially in the transformer secondary, the series regulator Transistor Q6, and the 10 ohm resistor. The transformer cannot be overstressed with this amount of current.

In the shorted output condition the emitter of transistor Q6 is at 0.5 volts and the collector at about 12 volts. Therefore the power dissipation is:

$$\begin{aligned} P &= (11.5v)(0.05a) \\ &= 0.57 \text{ watt} \end{aligned}$$

This transistor (NS942) is rated at 1.0 watt for case temperature of 100°C. In tests conducted at Spacelabs, the case temperature stabilized at 80°C in free air after continuous shorted output condition. In the potted module, heat transfer to the potting compound and to the module case occurs at a faster rate than in free air to the ambient, causing the transistor case temperature to decrease. Therefore no failure of the series regulator will occur since its power rating is not exceeded.

The power dissipated in the 10 ohm resistor is:

$$\begin{aligned} P &= (0.05)^2(10) \text{ watt} \\ &= 0.025 \text{ watt} \end{aligned}$$

which is well below the rated wattage of 0.125 watt.

Converter Input Circuit

The maximum input current to the converter is 100 ma. In the event of a short at both converter outputs, the negative supply shuts off due to the loss

of positive bias voltage. Therefore, the maximum input current should not exceed 100 ma even in the event of a short circuit at both converter outputs. Diode CR1 (MC8874) is rated at $I_f = 200$ ma, and therefore this component will not be overstressed.

Under worst case condition which would be 20.8 volts d. c. input, the power dissipated in transistor Q1 (2N1711) is approximately:

$$\begin{aligned} P &= (V_{CE})(I) \\ &= (20 - 11.4) (100 \times 10^{-3}) \text{ watt} \\ &= 0.86 \text{ watt} \end{aligned}$$

The rated wattage of transistor Q1 is 3.0 watts at 25°C case temperature and 1.7 watts at a case temperature of 100°C. In tests conducted at Spacelabs under ambient conditions, the case temperature never rose above 96°C. In the operational module this transistor has a heat sink which will allow for a lower case temperature. Therefore even under the stated worst operating conditions, transistor Q1 will not fail due to overheating.

The d. c. current in the transformer primary will not overstress the transformer.

Operation After Removal of Shorted Condition

When the short is removed the decrease in current is sensed by the current limiting circuit and transistor Q5 turns off. The potential at the emitter of Q6 increases allowing the regulation loop to be re-established. The rise of the output voltage from 0.0 volts to 10 volts is exponential due to the charging of capacitor C6.

CONCLUSION

The addition of the 10 ohm resistors to the converter outputs cannot cause overstressing or overheating of any component in the converter upon application of a short to the output.

Spacelabs, Inc.

DRAWING LIST

DC-DC CONVERTERS (Modified)

BLOCK II APOLLO

NAS 9-7854

Spacelabs, Inc.						DRAWING LIST							REV				DL	
PREP BY												REV PER EO		APPVL		SHEET 2 OF		
PROJ ENG																		
Q.A. ENG																		
MFG ENG																		
JOB NO.		5333		DC-DC Converter								DESCRIPTION						
ITEM	DRAWING NO.									REV	DESCRIPTION				Size	REMARKS		
1	1	0	4	8	4	4				-	PDA Test Procedure	A						
2	1	0	4	8	4	5				-	PDA Data Sheet	A						
3	1	0	3	4	5	7				-	Temperature Test Procedure	A						
4	1	0	4	8	5	7				-	Temperature Test Data Sheet	A						
5	1	0	3	6	5	9				-	Burn-In Test Cable	Roll						
6	1	0	3	6	5	3				A	Test Unit	D						
7																		
8	1	0	4	8	4	0				-	Outline Drawing	C						
9	1	0	4	8	4	3				-	Top Assembly	C						
10	1	0	4	8	4	7				-	Approved Parts List	A						
11	1	0	4	8	4	1				-	Parts List	A						
12	1	0	4	2	4	8				-	Components Parts Board	D						
13	1	0	4	8	4	8				-	Components Parts Assembly	D						
14	1	0	4	8	4	2				-	Schematic	D						
15	1	0	4	8	4	6				-	Nameplate	D						
16	1	0	3	9	8	6				B	Case Potting	C						
17			1	0	2	8	7	0		E	Case Potting Assembly	B						
18			6	1	0	0	0	1		A	Freeze Coat Process Spec (Weld Module)	A						
19			6	1	0	0	0	6		C	Potting Welded Module	A						
20			6	1	0	1	0	1		B	Process Spec Welded Module Mfg.	A						

[illegible]