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NASMS REPAIRS & IMPROVEMENTS

Final Report

A.J Keist
MetOcean Data Systems Limited
21 Thornhill Drive
Dartmouth, NS B3B 1R9

Contract Number W7707-008127/001/HAL
Contractor's Report Number HAL-0-40230

Defence R&D Canada

DEFENCE RESEARCH ESTABLISHMENT ATLANTIC

Contractor Report
DREA CR 2001-046
March 2001

National Defence Défense nationale

Canada

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Defence Research Establishment Atlantic

Contractor Report

DREA CR 2001-046

2001-03-31

Contract Scientific Authority

David G. Hazen

Approved by

David Chapman

H/NSS and TIAPS PM

Approved for release by

Kirk Foster

DREA DRP

Abstract

This contract addresses the NASMS design issues which became evident during the Q248 Sea Trial. These include a heat dissipation problem and high power transmission survivability.

Résumé

Le présent contrat porte sur les problèmes de conception du NASMS qui sont devenus évidents au cours de l'essai en mer Q248 et qui ont trait, notamment, à la dissipation de chaleur et à la survivabilité en conditions d'émission à puissance élevée.

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Executive summary

The NonAcoustic Sensor Multiplexing System (NASMS) is designed to collect and transmit engineering data from the Horizontal Projector Array (HPA), part of the Towed Integrated Active Passive Sonar (TIAPS). This data includes array depth and heading as well as the status of air reservoirs in the array. NASMS was designed and built by MetOcean under subcontract to Sparton of Canada as part of the HPA procurement. On the Q248 trial, the NASMS system failed. MetOcean was contracted to investigate the failure and make design changes, as required, to reduce the likelihood of the problem occurring again This report documents their findings that point to the failure of a capacitor that was mounted under a voltage regulator. In normal operation, the voltage regulator runs hot and sustained exposure to the heat caused the component to fail. The modified design removed the regulator from the printed circuit board and improved convective airflow through the electronics canister.

Keast, Andrew J. 2001. NASMS Repairs & Improvements: Final Report. DREA CR 2001-046 Defence Research Establishment Atlantic.

Sommaire

Le système de multiplexage à capteur non acoustique (NASMS) est conçu pour recueillir et transmettre des données techniques du réseau de projecteurs horizontaux (HPA), qui fait partie du sonar actif-passif intégré remorqué (TIAPS). Ces données indiquent notamment la profondeur et le cap du réseau, ainsi que l'état des réservoirs d'air dans le réseau. Le NASMS a été conçu et fabriqué par MetOcean en vertu d'un contrat de sous-traitance conclu avec Sparton of Canada Ltd., dans le cadre du projet d'acquisition du HPA. Dans l'essai Q248, le NASMS n'a pas bien fonctionné. Un contrat a été conclu avec MetOcean pour qu'elle analyse la défaillance et apporte des modifications de conception, au besoin, afin de réduire le risque de réapparition du problème. Le présent rapport décrit les résultats obtenus par MetOcean, qui mettent en évidence la défaillance d'un condensateur monté sous un régulateur de tension. En conditions d'utilisation normales, le régulateur de tension devient chaud et l'exposition soutenue à la chaleur a causé la défaillance du composant. La modification de conception consiste à enlever le régulateur de la carte de circuits imprimés et à améliorer l'écoulement d'air convectif dans l'enceinte électronique.

Keast, Andrew J. 2001. NASMS Repairs & Improvements: Final Report. DREA CR 2001-046 Defence Research Establishment Atlantic.

Distribution list

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NASMS
Repairs & Improvements
Final Report

Contractor Report Prepared for:

Defence

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Atlantic

by

Andrew J. Keast

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TABLE OF CONTENTS

1. AS RECEIVED FUNCTIONALITY **1**

1 1 TEMPERATURE TESTS 1

2. POTENTIAL SOLUTION **2**

2 1 POST MODIFICATION TEMPERATURE TESTS 2

3. TRANSIENT TESTS **4**

4. FALSE TRIGGERS. **5**

5. REVIEW MEETINGS **6**

6. POST REVIEW TEST **7**

7. DELIVERABLES **8**

8. UPDATED DOCUMENTATION. **8**

NASMS bench tests

1. As received Functionality

1. NASMS Shipboard unit powered up without the wet end. The display read all data set to high as expected (see users manual page 19), the power supply status was observed at 138 volts 0 002 A

2. The canister glass to metal seals were cleaned of excess solder and straightened to align with METOCEAN test jig.

3. The wet end was removed from the canister and C58 observed. The replacement fitted by DREA was of a different type and size than that originally fitted.

4. The blue Sparton test box was opened and the spare wet end removed and placed in storage (note C58 is not present on this unit). The 20 pin ribbon cable was then connected to the wet end previously removed from the canister via the METOCEAN test jig. It is to be noted that C58 is located directly under U27, this is one of the hottest locations in the stack.

5 A 30 volt power supply was connected to the wet end via the test box pins 19 (positive) and 20 (negative). See drawing 30-13331 NASMS WET END INTERCONNECT. The supply voltage was raised slowly confirming that D1 of drawing 30-13361 NASMS WET END SYSTEM SCHEMATIC was functional by observing a significant increase in current draw above 31 volts.

The wet end output from the Sparton test box was then connected to the shipboard receiver.

1 Shipboard unit powered up with the wet end. The display read the Zero calibration diagnostic sequence as expected (see users manual page 19), the high voltage power supply was turned off for this test.

2. A 5000 ohm variable resistor and an ammeter were connected to the wet end via the test box pins 15 (positive) and 16 (negative). See drawing 30-13331 NASMS WET END INTERCONNECT. The resistance was varied slowly and the AFT depth observed confirming that that channel was functional. 4.0 mA read -0.9 m, 12.0 mA read 255.7 m and 20.0 mA read 512.7 m

1.1 Temperature tests

The ambient air temperature was measured to be 28°C

With the wet end removed from the canister out of the foam out of the mylar wrap the temperature of U27 measured using a YSI44033 thermistor was 68°C. The voltage at U27 pin 2 was measured at 5.16 volts.

Tests with mylar and foam out of the canister were not deemed representative due to difficulty constraining the foam

With the wet end wrapped in mylar placed in the foam and inserted into the canister the temperature of U27 measured using a YSI44033 thermistor was 109°C. The voltage at U27 pin 2 was measured at 5.14 volts.

2. Potential solution

With the foam in place the only area where heat can readily escape to the canister is via the end cap. To avoid changing the design of the foam it is recommended that the two end (4-40 by 0.75 inch) spacers be replaced by an aluminum bar 0.75" by 2.25 by 0.25". This bar can be used to attach U25 and U27 removing the heat generation from the center of the stack and providing a much greater area to dissipate the energy. 4-40 tapped mounting hole spacing for the bar is 1.75 inches, 4-40 tapped mounting hole spacing for U25 and U27 is 0.75 inches, centered on the center of the bar. Two TO220 heatsinks were added to the end cap side of the bar using U25 and U27 mounting studs.

To avoid potential problems with components that have been exposed to elevated temperatures U25,U27, R64, C70 and C58 will be replaced. These components are associated with the 5 and 15 volt regulators that remained functional.

Each regulator has a current draw of approximately 100 mA. U27 has a power dissipation of 2.5 watts and U25 has a power dissipation of 1.5 watts. The thermal resistance from junction to case of these devices is 4 degC / watt

2.1 Post modification temperature tests

The ambient air temperature was measured to be 27°C

With the wet end removed from the canister out of the foam out of the mylar wrap the temperature of U27 measured using a YSI44033 thermistor was 52°C. The voltage at U27 pin 2 was measured at 5 18 volts.

With the wet end wrapped in mylar placed in the foam and inserted into the canister the temperature of U27 measured using a YSI44033 thermistor was 75°C. The voltage at U27 pin 2 was measured at 5 18 volts.

The above post modification tests were conducted without any compass load. U25 now shares the same heat-sink so the test was continued but with a 150 ohm load representing the compass load

A 150 ohm resistor was connected to the wet end via the test box pin 2 (positive) and the canister case (negative). See drawing 30-13331 NASMS WET END INTERCONNECT. The voltage present on pin 2 was 15 22 volts.

After a period of one hour the voltage present on pin 2 of the test box was 15 22 volts, the voltage at U27 pin 2 was measured at 5.18 volts and the temperature at U27 was 95°C.

It is to be noted that at this time the temperature of the outside of the canister was noticeable above ambient temperature. It is also to be noted that U25 and U27 are now physically removed from the printed circuit board thus the board temperature will be much less than the regulator temperature.

Each regulator has a current draw of approximately 100 mA. U27 has a power dissipation of 2.5 watts and U25 has a power dissipation of 1.5 watts. The thermal resistance from junction to case of these devices is 4 °C / watt, thus the junction temperature of U27 will be 105 °C. This is well below the maximum recommended operating temperature of 125 °C for these devices.

From a thermal perspective the regulators should be coupled to the canister, however this is a high vibration point so they were located inside the foam for mechanical (and unfortunately thermal) isolation This will raises the internal temperature of the canister significantly.

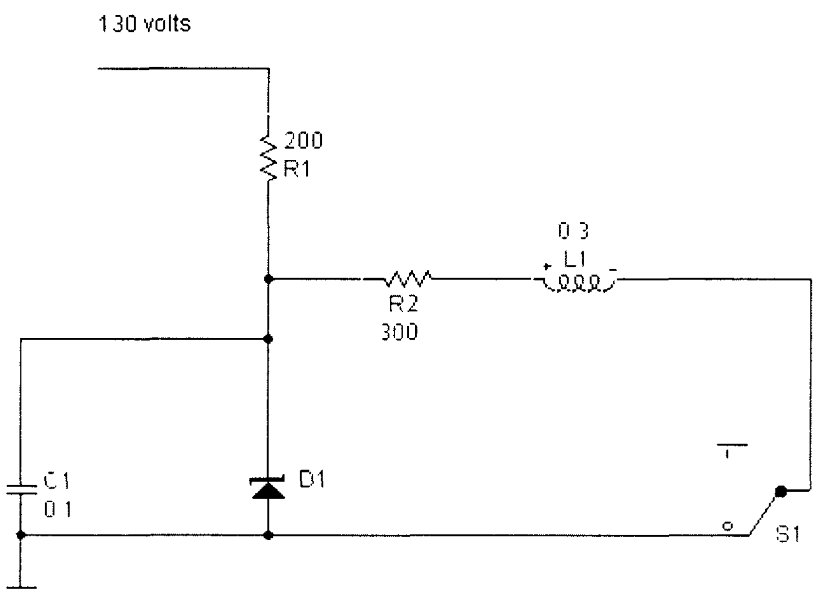
The above modifications are recommended for one unit at this time, they are a compromise between thermal and vibration performance. If the modifications prove successful at sea they should be applied to the spare NASMS transmitter unit, an upgrade parts kit has been provided.

3. Transient tests

To avoid damaging the operational NASMS hardware transient tests were applied to the independent test circuit shown below. The zener diode and capacitor are the same type as used within NASMS, the resistors are wire wound types and are inductive.

With S1 being changed from closed to open the energy stored in L1, a 300 mH inductor is introduced to the zener diode via a 300 ohm resistor. Voltages were recorded at the switch, at the zener diode and at the capacitor.

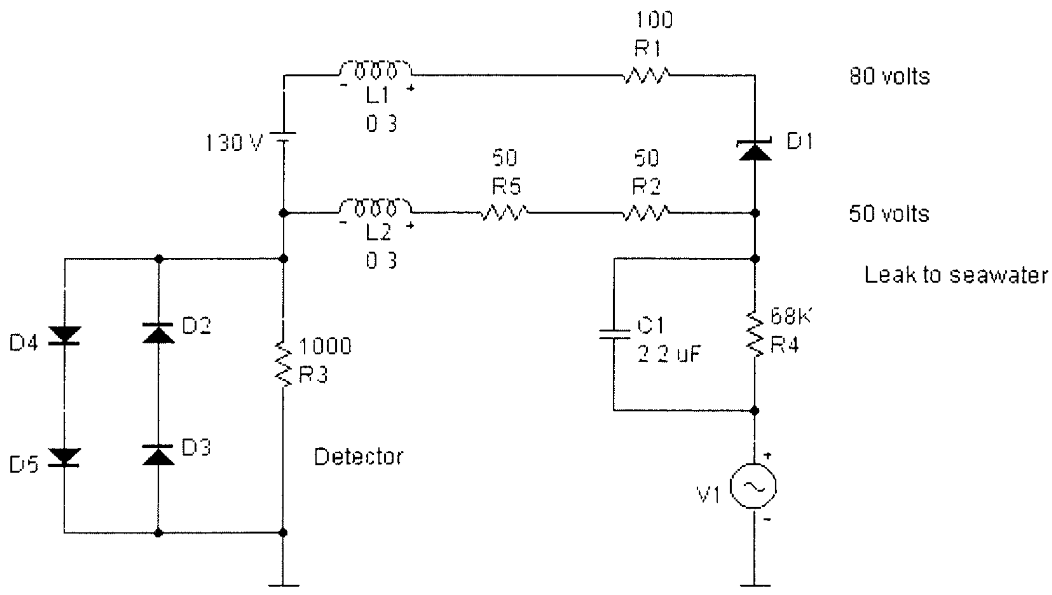
Measurement point	Results
At S1	400 volts pk-pk, over a period of 200 microseconds Spikes of 100 nanoseconds were present.
At D1	Approximately 5 volts pk-pk, maximum 31.8 volts minimum 26.4 volts.
At C1	Approximately 4 volts peak to peak, maximum 33.9 volts minimum 29.4 volts, spikes of 15 nanoseconds were present. The mean zener voltage was 31.25 volts



Based on the above results the transient protection afforded by the Zener diode is adequate for the NASMS design, no changes are recommended.

4. False Triggers.

The MID EASTERN INDUSTRIES HWD series power supply ground fault circuit connector was mated The supply was then turned on and the power supply status was observed at 138 volts 0 002 A.
The following circuit was then connected, note that R5, L1, and L2 are contained within the NASMS receiver. R3 represents the sea water leak detector internal to the power supply and R4 the leak to seawater R1 and R2 represent cable resistance and D1 represents the NASMS transmitter



With R4 at 68 K ohms the leak current was measured at 0 7 mA. With a parallel capacitor of 2 2 uF added to R4 the leak current remained stable and the power supply did not trip even when the capacitor was charged to ± 50 volts prior to being connected. With R4 set to 40 2 K the power supply always tripped. The above operation is as designed. That is a leakage current of 1 mA will cause the power supply to trip. No false triggers were observed below this leakage current.

Due to personnel safety concerns it is recommended that this circuit is used at the above sensitivity. As a diagnostic procedure it is possible to measure the leakage current and desensitize this circuit by placing a resistor in parallel with R3. This can be accomplished by connecting a voltmeter and resistor to the power supply front panel black and white banana jacks labeled "-" and "GND". The power supply will trip when the voltage across this resistor reaches approximately 1 volt.

Parallel Resistor	Approximate Trip current
Open circuit	1 mA
110Ω	10 mA
20Ω	50 mA
10Ω	100 mA

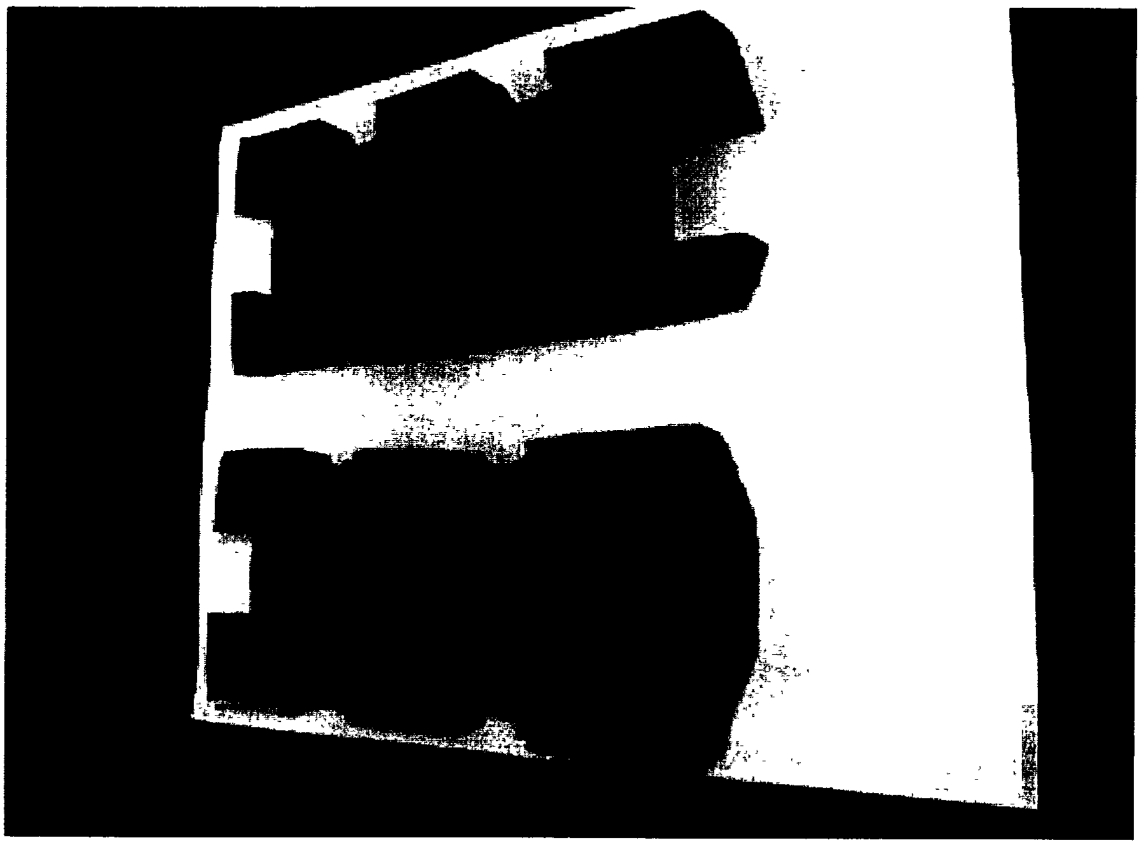
With the sine wave source injecting a 100 volts rms at 1000 Hz in series with the leak path (R4 68KΩ) the power supply did not trip out. With a 2.2 uF in parallel with R4 the power supply still did not trip out.

With the sine wave source injecting a 50 volts rms at 50 Hz in series with the leak path (R4 68KΩ) the power supply did not trip out. With a 2 2 uF in parallel with R4 the power supply still did not trip out, however intermittent connection of the capacitor caused the supply to trip with this interfering signal.

5. Review meetings

Based on review meetings between Dave Hazen, Yolande Bonin, Stu Hutton of DREA plus Paul Yeatman and Linus Siurna of Hermes on the 12th Sept, the consensus was to remove part of the foam packaging and add some surface area to the heat sink . This would allow more air circulation and hopefully reduce the temperature.

Two Wakefield 274-2 TO220 heat-sinks were added to the aluminum bar on the canister lid side. Foam was removed at the canister lid end from one side only. The other side has foam to prevent ribbon cable abrasion, this was left in place Foam was also removed from the cansiter end and from the sides as shown below



The board assembly was wrapped in mylar prior to being placed in the foam. Holes were cut in the mylar to align with the holes in the foam and allow air passage through to the canister.

With the electronics operational and a 150 ohm dummy load representing the compass, the temperature of U27 reached 90 °C after two hours of operation.

6. Post Review Test

To test the system signals were injected at the transmitter input and the results monitored at the receiver display and analogue outputs. Each analogue input was stimulated with input currents of nominally 4 or 12 mA. and full scale of 20 mA. For each state the display data and the analogue output voltage were recorded. Actual currents were those obtained from specific sensor calibration data.

Sensor	Zero current	Display	Output volts	full scale current	Display	Output volts
1 Forward Tank Pressure	4.0367	0.0 %	-0 001	20 037	100 0%	10.004
2 Aft Tank pressure	4.0634	0.0 %	-0.005	20.063	100 0%	10.07
3 Temperature	10.147	0 0 °C	-0.0005	19.983	40.0 °C	4.0001
4 Forward Differential Pressure	12.297	0.0 m	-0.006	20.302	68.5 m	6.858
5 Aft Differential Pressure	12.218	0.0 m	-0.006	20 1689	68.4 m	6.842
6 Forward Depth	4 004	0 1 m	-0.0003	19 937	513.2 m	5.135
7 Aft Depth	4.0265	0.1 m	-0.000	20 021	513.3 m	5 130

The compass input was not tested, however the self test provided a data set to verify the compass analogue outputs:-

Sensor	Display	Output volts
Heading	93.2	0.937
Roll	94.6	0.943

7. Deliverables

To facilitate timely integration into the HPA the following hardware was delivered to DREA on 15th September 2000.

1. Non-Acoustic Sensor Multiplexing System (NASMS) Receiver. Mod. HWD200-1B-06-49,S/N 297271. Evaluated and tested.

2. NASM transmitter Evaluated repaired modified and tested.

3. Power Inductor, Hammond Mod. 159ZA.

4 Unmodified Spares hardware plus a kit of parts to upgrade the spares.

5. Test results in draft form.

On 31st March 2001, six paper copies of this report plus a CDROM in HTML and Adobe PDF format were delivered.

8. Updated documentation.

The updated NASMS documentation consists of an updated parts list (Appendix A page 6 and 7) and three drawings:-

Drawing #	Title	Description
014618	Block Mounting	Aluminum block added to the assembly to allow power devices to be moved to the end of the assembly near a heat path to the lid.
014619	Heat sink block assembly	Detail of wiring and assembly of LM317 power regulators.
014624	NASMS foam insert modifications	Detail of foam removal to SPARTON supplied foam inserts.

2.2.6 Parts list for NASMS WET-END input board 13302

NASM WET END - INPUT   Revised. February 27, 2001
40-13300-00   Revision: 1

METOCEAN DATA SYSTEMS LTD

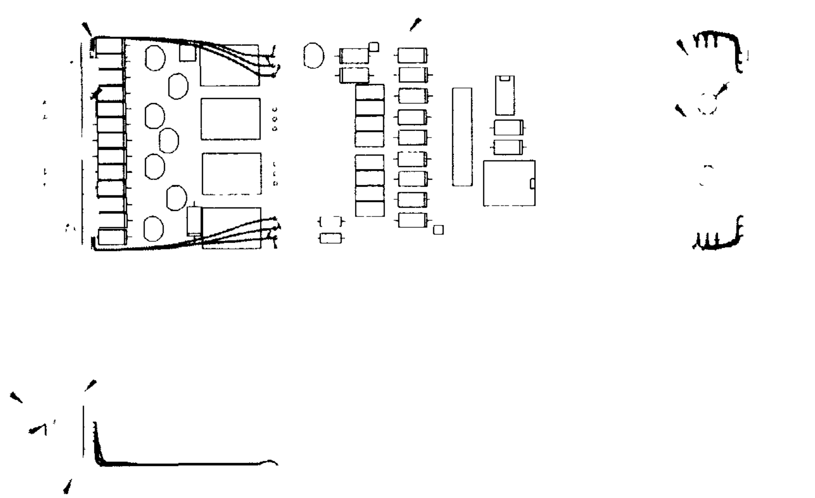
Bill Of Materials   February 27, 2001   18 25·25   Page 1

Item	Quantity	Reference	Part
1	14	C17,C18,C19,C20,C21,C22, C23,C55,C56,C58,C71,C72, C73,C77	100nF 10% 50V 1206 X7R CC1206 100104
2	8	C24,C25,C26,C27,C28,C29, C30,C76	1uF 10% 35V TANT 3528 101681
3	10	C61,C62,C63,C64,C65,C66, C67,C68,C69,C70	10uF 10% 25V SM7343 7343 101107
4	2	C74,C75	10nF 10% 400V 0.4LEAD POLYESTER 37241104 CK12 100059
5	16	D4,D5,D6,D7,D8,D9,D10, D11,D12,D13,D14,D15,D16, D17,D33,D34	1N4001 50V 1A DO41 DO7 100570
6	11	D18,D19,D20,D21,D22,D23, D24,D25,D30,D31,D32	1N4735 6.2V DO7 100744
7	1	JP1	HEADER 20 20CON200 100193
8	1	J1	BOARD CONNECTOR 20 PIN 20DRH100 102836
9	2	Q1,Q3	MMBT2222 SOT23 SOT23MET 100582
10	1	Q2	MTP2955 TO220H 102593
11	8	R25,R26,R27,R28,R29,R30, R31,R68	36 5 1% 1/4W SM1206 CC1206 102459
12	8	R32,R33,R34,R35,R36,R37, R38,R39	66.5 0.01 1/4W Thin Film LEADED150 102850
13	3	R56,R62,R64	200 1% 1206 CC1206 100798
14	1	R57	2 21K 1% 1/4W 1206 CC1206 101016
15	6	R58,R59,R63,R66,R67,R71	10K 5% 1/8W SM1206 CC1206 100488
16	2	R61,R60	100 5% 1/4W SM1206 CC1206 100534
17	1	R65	619 1% 1/4W 1206 CC1206 102842
18	2	R69,R70	20 5% 1/8W SM1206 CC1206 101397
19	1	TM1	TERMINAL TERMINAL 102442
20	2	TP16,TP18	TP* TESTPAD
21	1	T1	2745B PULSE_XFORMER_2745AF2 102851
22	8	U13,U14,U15,U16,U17,U18, U19,U28	LM317LZ TO92* 102843
23	1	U29	LM317* TO220H 101507
24	1	U26	LTC485 8DIP300 102654

25	0	U27	NOT LOCATED ON THIS BOARD
26	0	_BUSHING	NOT LOCATED ON THIS BOARD
27	1	_EPOXY	EPOXY 14310 102347 AS REQ'D
28	1	_HEAT SINK	Heat Sink Block Assembly 014619-101
29	1	_LOCTITE	LOCTITE 222 100114 AS REQ'D
30	1	_NUT	NUT,HEX,SS,4-40 100283 QTY. 4
31	1	_SCREW	SCREW,MACH,SS,4-40x0 38 BHPD 102170

QTY 4

REVISIONS



QTY	U/M	ITEM	PART NUMBER	DESCRIPTION
1	EA	1	13300	PCB ASSY NASM,WET END-INPUT
1	EA	2	014618-01	BLOCK MOUNTING
2	EA	3	102656	HEAT SINK TO-220 0 375"H
2	EA	4	100283	NUT,HEX SS,4-40
2	EA	5	102060	INSULATOR,MICA,RECT U/W TO220
2	EA	6	102061	BUSHING SHLDR NYL 6-32 F/TO220
2	EA	7	101319	SCREW MACH,SS, 4-40x0 50 PHPD
2	EA	8	101507	IC LM317 TO220 +VOLT REG ADJ
A/R	FT	9	100262	TUBING HEAT SHRINK 1/16"DIA B
A/R	FT	10	101630	WIRE HOOKUP 24AWG 7/32 BROWN
A/R	ROL	11	100471	SOLDER WIRE 60/40,0 75mmD,500g
A/R	EA	12	100114	LOCTITE 222 50mL BOTTLE
2	EA	13	102170	SCREW,MACH SS 4-40x0 38 BHPD
A/R	FT	14	100609	WIRE,HOOKUP,24AWG,7/32,RED
A/R	FT	15	101631	WIRE HOOKUP 24AWG 7/32,ORANGE

UNLESS OTHERWISE STATED
TOLERANCES x.xx ±0.02 ANGULAR ±1/2
x.xxx ±0.010 FRACTION ±1/
RADIUS/CHAMFER ALL SHARP CORNERS 0.04±0.02
DIMENSIONS ARE IN INCHES

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14. ABSTRACT

(U) This contract addresses the NASMS design issues which became evident during the Q248 Sea Trial. These include a heat dissipation problem and high power transmission survivability.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) NASMS; TIAPS; HPA; Horizontal Projector Array

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