NASA Technical Memorandum

NASA TM- 100367

AN EVALUATION OF THE GENERAL DYNAMICS 20 kHz 5 kW BREADBOARD FOR SPACE STATION ELECTRICAL POWER AT MSFC

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May 1989

National Aeronautics and Space Administration

George C. Marshall Space Flight Center

MSFC - Form 3190 (Rev. May 1983)

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TECHNICAL MEMORANDUM

AN EVALUATION OF THE GENERAL DYNAMICS 20 kHz 5 kW BREADBOARD FOR SPACE STATION ELECTRICAL POWER AT MSFC

INTRODUCTION

In January 1988, General Dynamics Space Systems Division, San Diego, California, delivered to Marshall Space Flight Center, Electrical Power Systems Team (EB12) a 20 kHz, 5 kW, AC Power Processing Breadboard. This breadboard takes 120/208 Vac, 3-Phase, or 200 Vdc Power, converts it to 440/762 Vac, 3-Phase (or 1-Phase) power on a 50 meter transmission bus, then converts it to five "user oriented" forms of power.

The breadboard is comprised of the following components:

Driver Modules (3 total), 1667 W each
- Input: 120/208 Vac, 3-Phase, 60 Hz, or 200 Vdc
- Output: 440 Vac, 20 kHz

Inverter Fault Isolation Switches (6 total)
- Computer Controlled

Power Bus (2 total), Single or Three Phase
- Length: 50 meters

User Load Modules (5 total)
- 120 Vac, 60 or 416 Hz, 500 W, Single Phase
- 120/208 Vac, 416 Hz, 1 kW, Three Phase
- 120/208 Vac, 13-3333 Hz, 1 kW, Three Phase
- 28 Vdc, 1 kW
- 150 Vdc, Bi-Directional, 1 kW
  - Input/Output: 440 Vac, 20 kHz, Three Phase
  - Output/Input: 150 Vdc

User Load Fault Isolation Switches (14 total)
- Computer Controlled

Control and Fault Isolation Computers
- Inverter Control Computer and Software
- Load Control Computer and Software
- User Interface Console Printer and Software [1].

Figure 1 is a block diagram of the breadboard. This paper will discuss the total harmonic distortion of the DC Receiver measured at both ends of the 50 meter-line, and harmonic traps as a solution to the problem of different waveforms at each end of the line.

The problem of ground circulating currents will also be addressed.

DISCUSSION

The Total Harmonic Distortion (THD) at both ends of the 50-meter transmission line was measured using a Tektronix 7854 oscilloscope and waveform calculator under two conditions: with only one driver on and with all three drivers on. Both of these conditions were measured at two different power levels: 1/2 kW and 1 kW.

Figures 2 and 3 show current and voltage traces at the driver and receiver ends of the 50-meter cable using only one driver at 1/2 kW and the V and I THD percentage values at each point. Figures 4 and 5 show these measurements at 1 kW. Figures 6 and 7 show traces with three drivers on at 1/2 kW, and Figures 8 and 9 show traces with three drivers at 1 kW.

As these figures show, the voltage THD increased from the driver to the receiver end, which was to be expected with a nonlinear load.

The current THD, however, was greater at the driver end because of harmonic amplification caused by resonant parasitics in the transmission line [2].

In order to filter the distortion on the line, an RLC Filter was constructed. Figure 10 shows the actual harmonic trap used. A transformer was used to make instrumentation easier and safer for the user, by being able to tie to the oscilloscope's ground. Figure 11 shows a dual trace of currents at the driver and receiver ends before harmonic damping and Figure 12 shows the same traces with harmonic damping. As Figure 12 shows, the harmonic trap greatly reduced the distortion in the line.

The systems ground currents were measured and the highest value was 0.92 A. Although no definite explanation was found for such high ground currents, one reason suspected is SCR's not being electrically isolated from their heat sinks.

Isolation of all the power semiconductors from their heat sinks would offer a partial solution to the circulating ground current's high value, however, it would not necessarily lower them to a safe and acceptable level.

CONCLUSION

The GD Breadboard was useful in that it brought to light several problems associated with a 20 kHz Power System.

The two main problems discussed in this paper, harmonic distortion and ground current, demonstrate that this 20 kHz power system may not be suitable for utility space applications.

REFERENCES

1. General Dynamics Space Systems Division: 20 kHz AC Power Processing Breadboard Operations and Service Manual.

2. Lollar, L.F.: Power Quality Load Management for Large Spacecraft Electrical Power Systems. NASA Technical Memorandum 100342, September 1988.

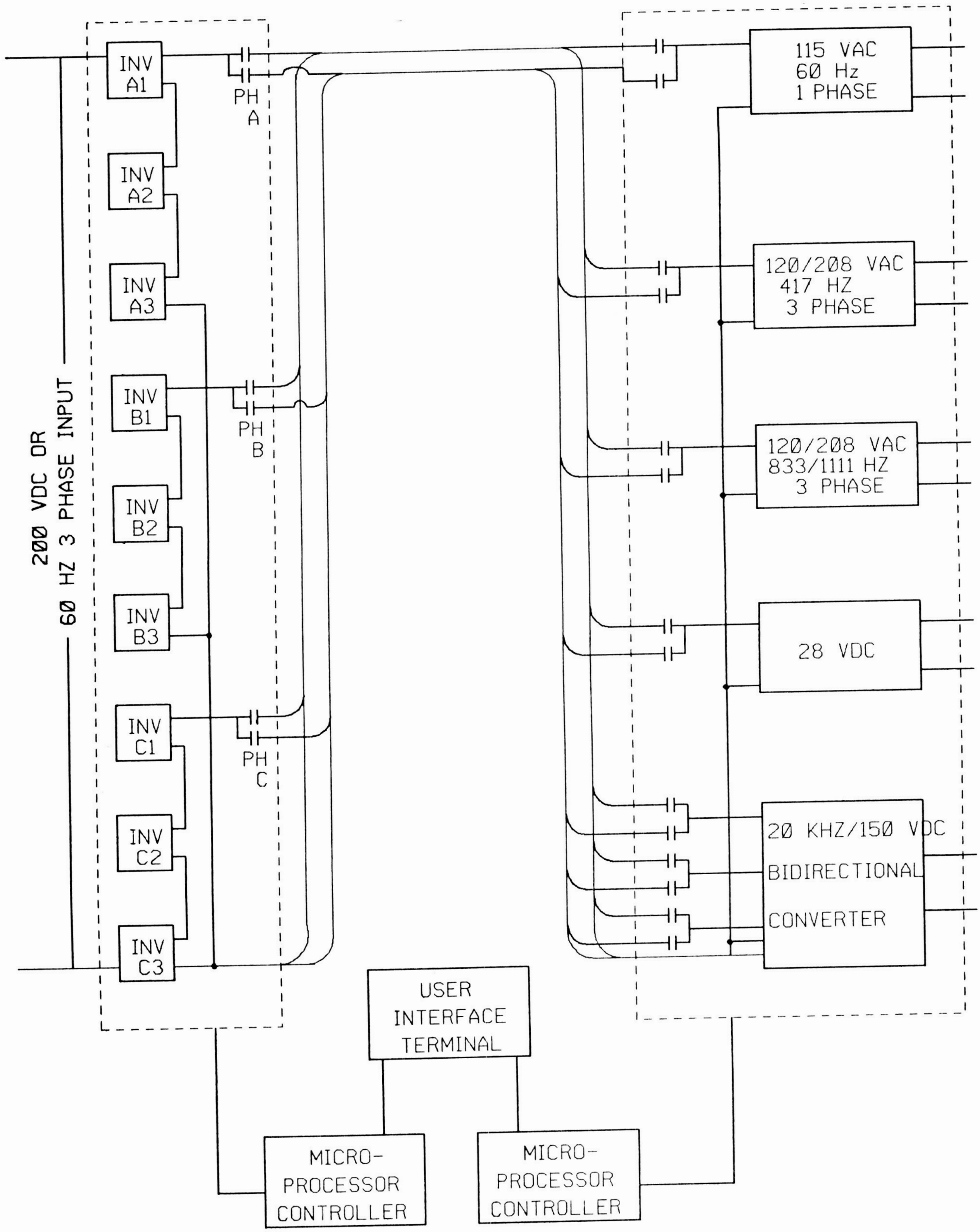

Figure 1. MSFC 20 kHz Breadboard.

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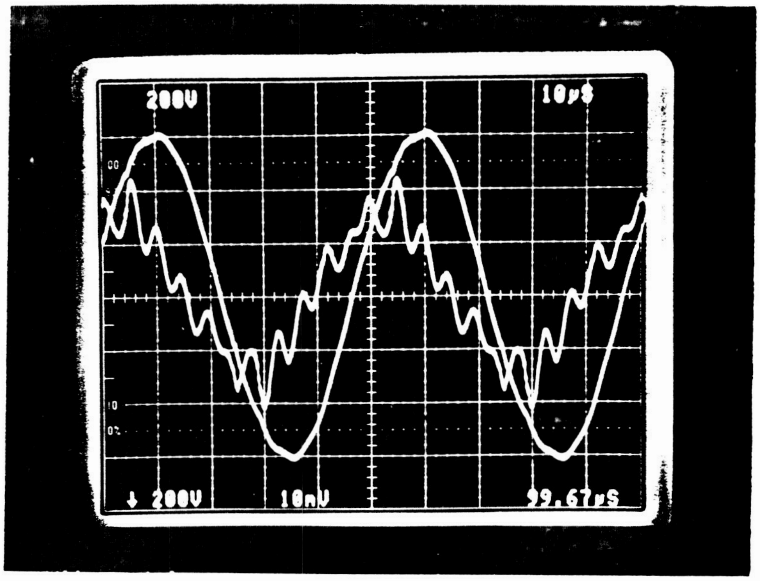

Figure 2. Driver end, 1/2 kW, 1 driver, I_{THD} = 24.8 percent, V_{THD} = 2.75 percent.

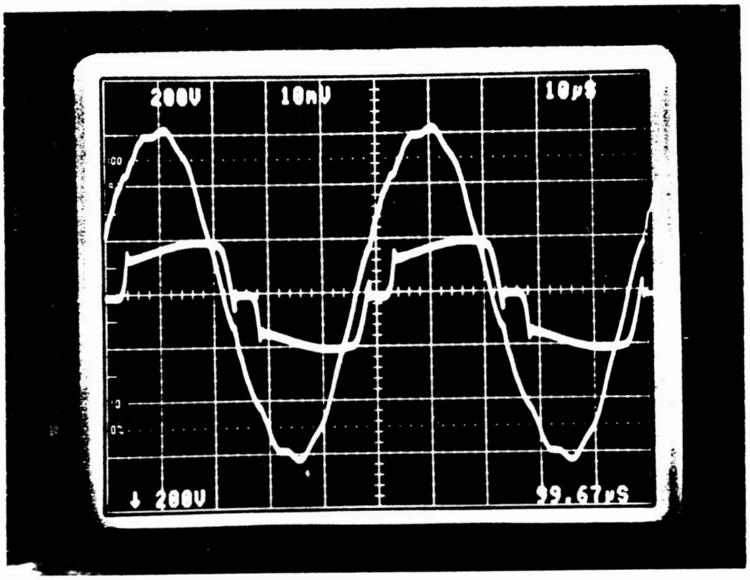

Figure 3. Receiver end, 1/2 kW, 1 driver, I_{THD} = 21.1 percent, V_{THD} = 3.04 percent.

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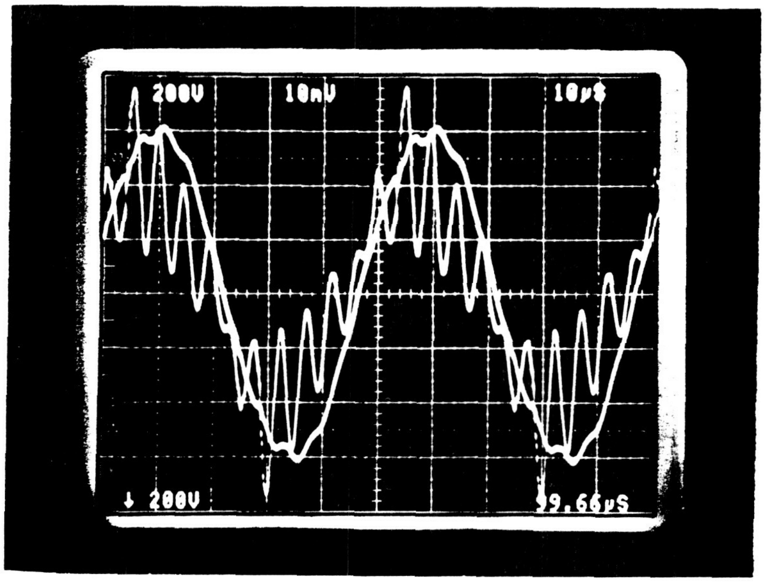

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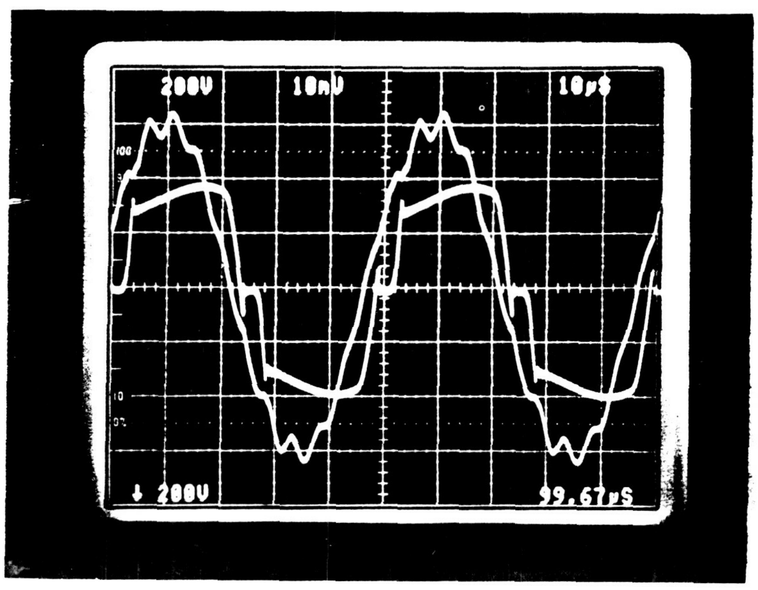

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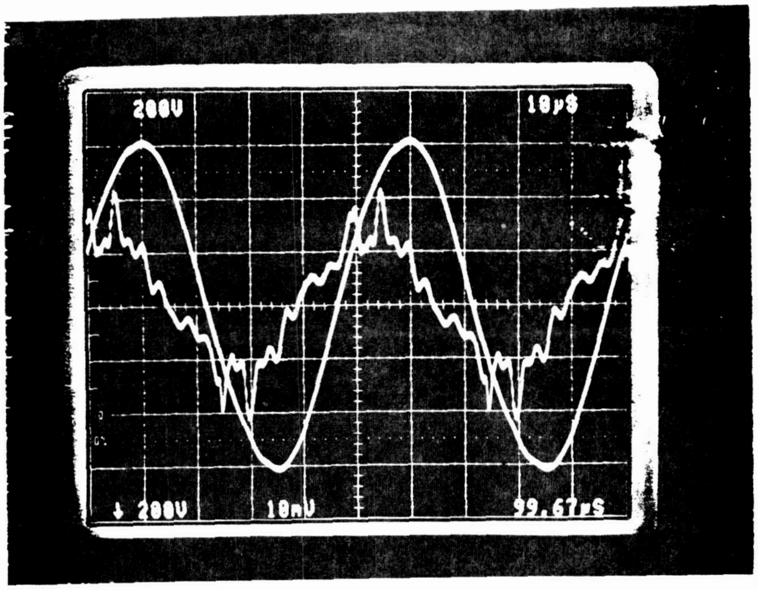

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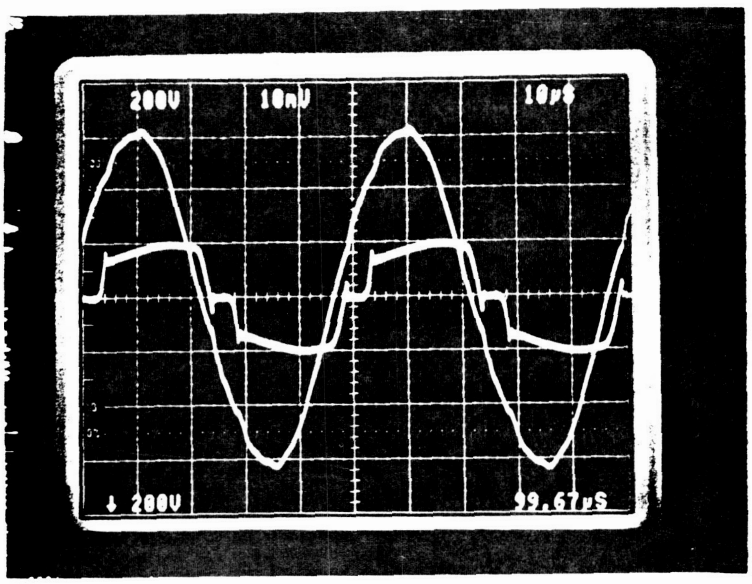

Figure 7. Receiver end, 1/2 kW, 3 drivers, I_{THD} = 20.5 percent, V_{THD} = 2.70 percent.

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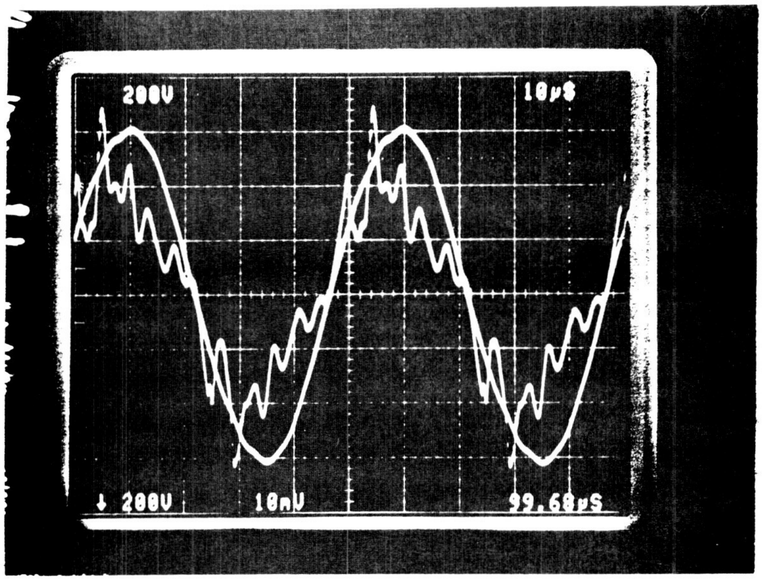

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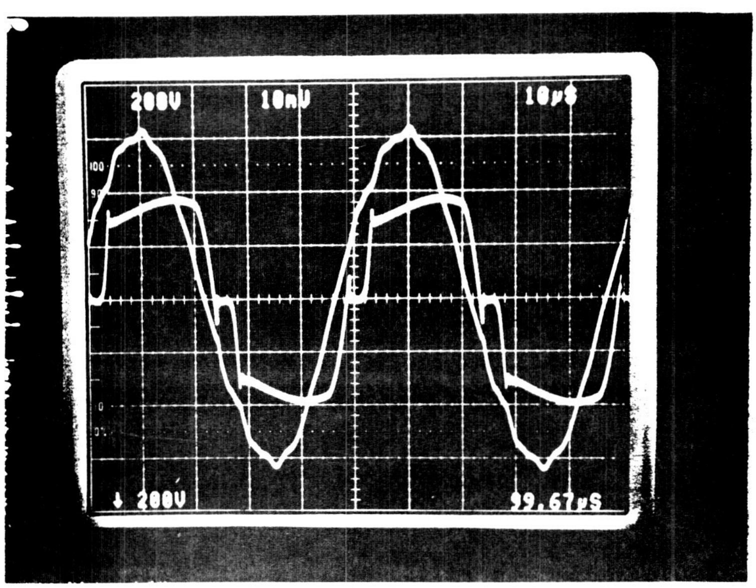

Figure 9. Receiver end, 1 kW, 3 drivers, 2 A/DIV, I_{THD} = 20 percent, V_{THD} = 3.27 percent.

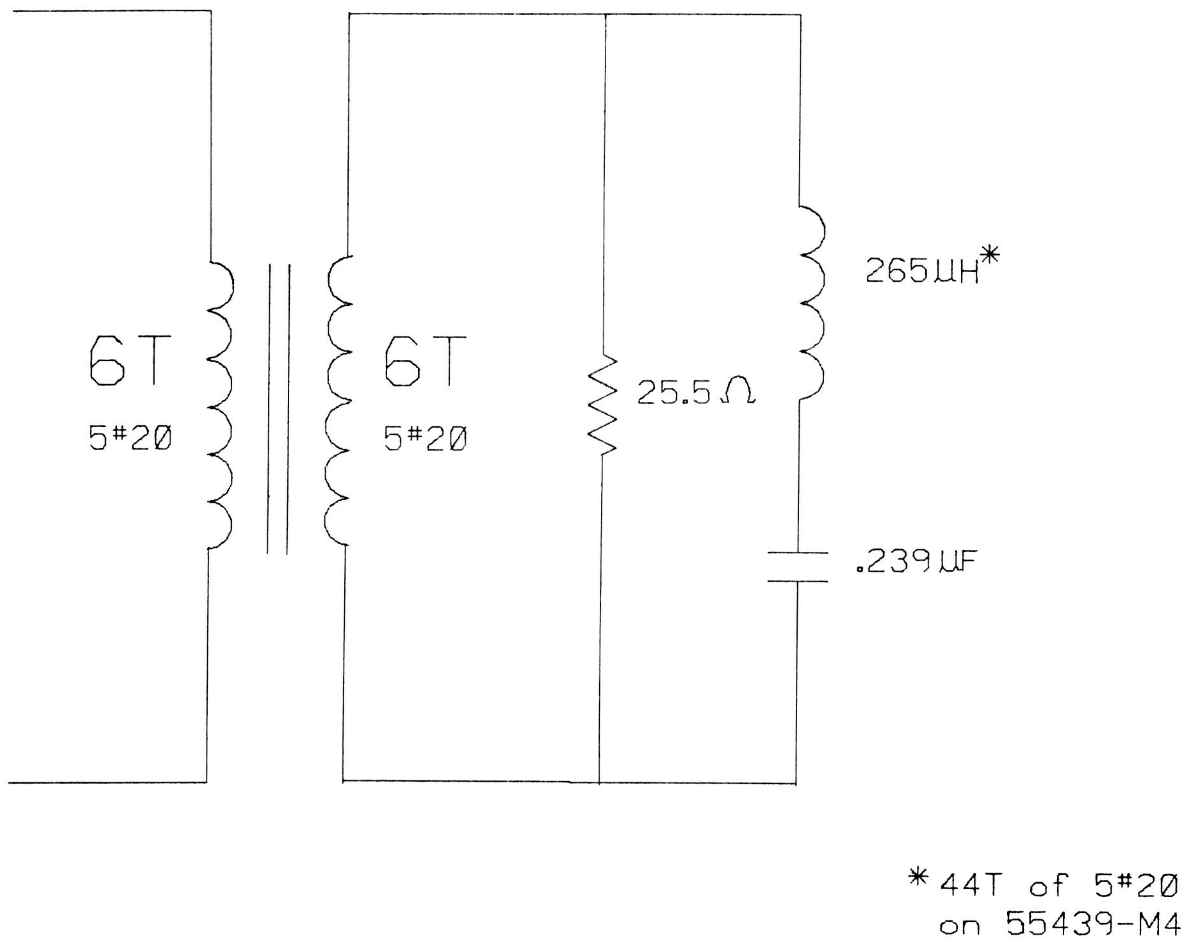

Figure 10. Harmonic trap.

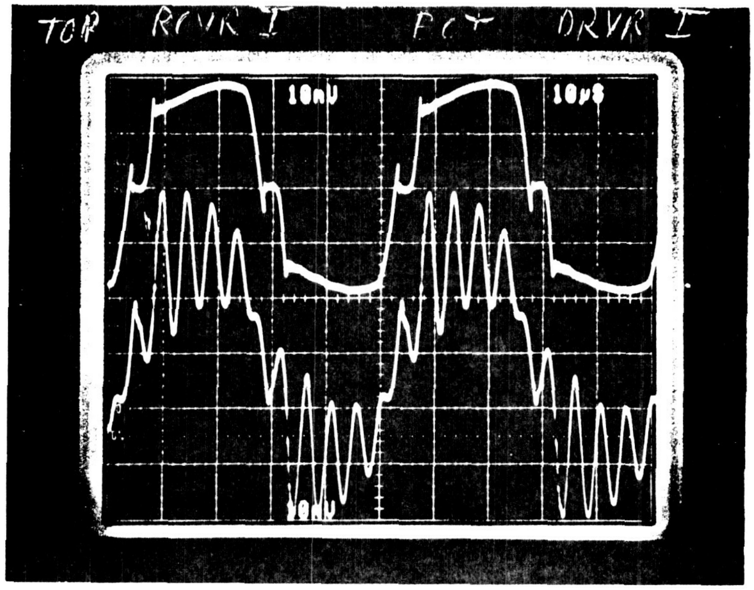

Figure 11. Receiver and driver currents before damping.

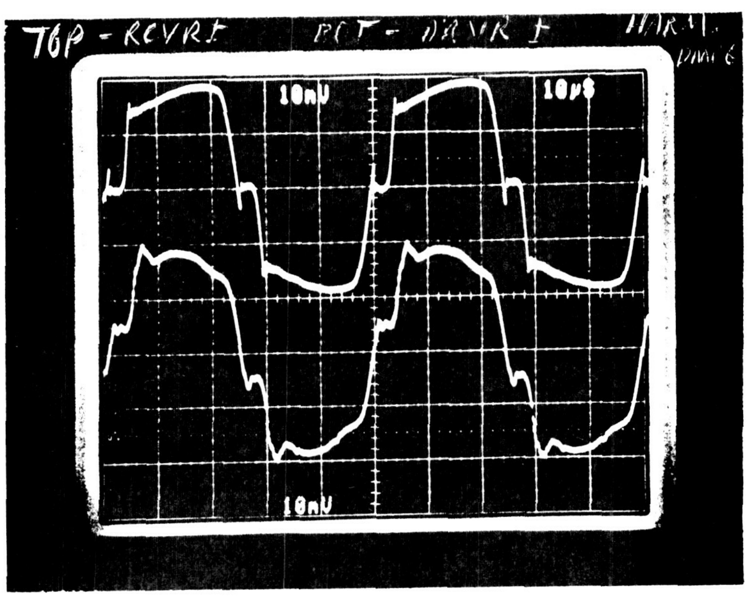

Figure 12. Receiver and driver currents with harmonic damping.

APPROVAL

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The informatin in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

WILLIAM B. CHUBB
Director, Information and Electronic Systems Laboratory

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA TM-100367		

4. TITLE AND SUBTITLE An Evaluation of the General Dynamics 20 kHz 5 kW Breadboard for Space Station Electrical Power at MSFC	5. REPORT DATE May 1989
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) David K. Hall and Robert E. Kapustka	8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D.C. 20546	13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared by Information and Electronic Systems Laboratory, Science and Engineering Directorate.

16. ABSTRACT

This report discusses the results and observations of tests made on the General Dynamics 20 kHz Breadboard for Space Station Electrical Power. This study considers the General Dynamics 20 kHz system only, and not the issue of the use of 20 kHz AC Power for Spacecraft Applications.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
20 kHz 5 kW Space Station Electrical Power, THD in a 20 kHz AC EPS, Ground Currents in the 50 kW 20 kHz AC Power Breadboard, Harmonic Trap	Unclassified — Unlimited

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	15	NTIS

MSFC - Form 3292 (Rev. December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22151