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SIXTH QUARTERLY PROGRESS REPORT

1 OCTOBER 1977 TO 31 DECEMBER 1977

CONTRACT DAAB07 - 76 - C - 0041

# MANUFACTURING METHODS AND TECHNIQUES FOR MINIATURE HIGH VOLTAGE HYBRID MULTIPLIER MODULES

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The results of testing of rectangular and curved multipliers to the Second Engineering Sample requirements are presented.

Steps to improve the frequency performance of the multipliers and optimization of the rectifiers for these devices are discussed. Results of life testing of multipliers are presented.

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SIXTH QUARTERLY PROGRESS REPORT

1 OCTOBER 1977 TO 31 DECEMBER 1977

# MANUFACTURING METHODS AND TECHNIQUES FOR MINIATURE HIGH VOLTAGE HYBRID MULTIPLIER MODULES

CONTRACT NO. DAAB07 - 76 - C - 0041

PREPARED BY: DR. MICHAEL KORWIN-PAWLOWSKI

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# ABSTRACT

The progress made during the sixth quarter of work on the Manufacturing and Technology Program for Miniature High Voltage Multiplier Modules is described in this report.

The results of testing of rectangular and curved multipliers to the Second Engineering Sample requirements are presented.

Steps to improve the frequency performance of the multipliers and optimization of the rectifiers for these devices are discussed. Results of life testing of multipliers are presented.

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## PURPOSE

This Contract covers component designs, mounting and interconnection techniques, tooling and test methods and other manufacturing methods and techniques required for production of rectangular and curved miniature high voltage multiplier modules. These units are to be used in low cost power supplies for second generation image intensifier tubes. The full scope and details of the specification are given in SCS - 495, Appendix A to the First Quarterly Report.

Major milestones in this program consist of delivery of the following items:

(1) First and second engineering samples and test data.

(2) Production line layout and schedule.

(3) Confirmatory samples and test data.

(4) Production line set - up.

(5) Pilot production run.

(6) Production rate demonstration.

(7) Preparation and publication of a final report.

The general approach is to design and set - up a cost - effective production capability, utilizing already established device technologies and materials, and to demonstrate the production line capability to fabricate at the rate of 125 acceptable units per 40 hour week.

## GLOSSARY OF SPECIAL TERMS

| | | |
|---|---|---|
| Capacitor bank: | - | Ceramic wafer with metallizations which perform the function of a number of capacitors connected in parallel (parallel bank) or in series (series capacitor bank). |
| Cure: | - | To change the physical properties of a material by chemical reaction or by the action of heat and catalyst. |
| Flash test: | - | Test consisting of instantaneous application of voltage at its specified value to the part. |
| Hybrid: | - | Technology combining thick - films (capacitor banks) with discrete devices (rectifiers). |
| Multiplier Modules: | - | Device consisting of capacitor banks and rectifers connected and packaged to perform voltage multiplication and rectification. |
| Pad: | - | The metallized area on the ceramic bank acting as a plate of a capacitor and used to make an electrical connection to it. |
| Rectifier: | - | Semiconductor device with one or more p - n junctions connected in series. |

| | | |
|---|---|---|
| Rectifier - substrate Assembly: | - | A substrate with rectifiers placed and secured within it. |
| Substrate: | - | Part of a multiplier module consisting of a piece of insulating material machined to accommodate the rectifiers and support the capacitor banks. |

## LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| ic | - | charging current (μA) |
| $C_x$ | - | measured capacitance (pF) |
| D.F. | - | dissipation factor (%) |
| f | - | frequency (KHz) |
| $C_i$ | - | input capacitance (pF) |
| $I_L$ | - | load current (nA) |
| $v_r$ | - | ripple voltage (V) |
| $V_B$ | - | breakdown voltage (V) |
| $V_i$ | - | input voltage (Vp - p) |
| $V_o$ | - | output voltage (V d.c.) |
| $\eta$ | - | efficiency (%) |

# 1. INTRODUCTION

This report describes briefly the progress in the Manufacturing Methods and Techniques for Miniature High Voltage Hybrid Multiplier Modules Program, made during the latest calendar quarter.

In the First Quarterly Report the design and the manufacturing process for rectangular and curved multiplier modules were described. Prototype rectifier-substrate assemblies were fabricated and then redesigned to simplify the assembly operation. The specification covering the requirements for the multiplier modules forms Appendix A of the Report.

In the Second Quarterly Report results of the electrical evaluation of the first sample batch of rectangular capacitor banks TSK 25 - 250 and TSK 25 - 251 were given, the choice of the rectifier was made and electrical test results were presented on non-modular multipliers fabricated with TSK 25 - 250 and TSK 25 - 251 capacitor banks and standard HV20PD four-junction rectifiers, to evaluate these components.

In the Third Quarterly Report results of electrical tests on rectangular multiplier modules were presented. For an input voltage of 1 KV, efficiencies above 96% under no-load conditions and above 95% with 500 nA load currents were achieved for all multipliers assembled with TSK 25 - 250 and TSK 25 - 251 and three - chip rectifiers. Low ripple voltages, input capacitances and charging currents were also measured on these multipliers. Results of the mechanical and electrical evaluation of TSK 25 - 249 curved capacitor banks were also presented in the Third Quarterly Report.

In the Fourth Quarterly Report work on impregnation and coating of the multipliers was discussed as well as some problems associated with the fabrication of the rectifier - substrate assemblies. The fabrication of rectangular and curved multipliers for the First Engineering Sample was discussed.

In the Fifth Quarterly Report were presented the results of electrical performance testing at the room, high (+52 °C) and low (-54°C) temperatures, as well as effects of thermal shock, and high and low temperature storage.

## 2. FABRICATION AND EVALUATION OF MULTIPLIERS

### 2.1 Second Engineering Sample Tests

Fourteen curved (TSK 313 - 000) and seventeen rectangular (TSK 312 - 000) multipliers were tested in accordance with the applicable paragraphs of "Electronics Command Technical Requirement SCS 495" to the Second Engineering Sample requirements. The curved multipliers were fabricated in September 1977, while of the rectangular multipliers 8 were previously supplied as part of the First Engineering Sample submission and 9 were retained from the same lot for testing to the Second Engineering Sample requirements.

The results of testing were presented in the Report on Second Engineering Samples (Erie Technical Report No. 0019), dated October 21, 1977, and forming Appendix A of this report.

The devices satisfactorily passed the efficiency testing, at no load and under full load, and the ripple voltage tests, at room, high (+50°C) and low (-54°C) temperatures.

The thermal shocking and high temperature storage did not affect the devices adversely.

Problems were encountered with the input capacitance and charging current of the devices. The specification requires the charging current to be below 150 μA and the capacitance below 8 pF in the frequency range from 20 to 40 kHz.

Measured at the nominal frequency of 30 kHz, the average input capacitance was for the rectangular multipliers 7.91 pF and for the curved multipliers 9.30 pF. Five out of 17 rectangular, and all 14 curved multipliers were out of specification on this respect.

The input capacitance does not depend much on the signal frequency. The charging current, on the other hand, increases significantly with the frequency of the input voltage. Thus, typical charging current values at room temperature are:

| | | |
|---|---|---|
| 140 μA | @ | 20 kHz |
| 260 μA | @ | 30 kHz |
| 500 μA | @ | 40 kHz |

Previous tests were conducted at 20 kHz, and the devices were within the specification at that frequency.

It should be noted that the efficiency of the multipliers was found to be practically independent of the input voltage frequency in the range from 25 to 40 kHz. (See Second Quarterly Report, Table 3).

## 2.2 Optimization Of Semiconductor Rectifiers

The charging current and the input capacitance for multipliers of a given construction and the same stray capacitance depend very much on the electrical properties of the rectifiers used in the circuit.

The high-voltage rectifiers manufactured by Erie Technological Products of Canada belong to one of several series, optimized for particular applications, and technologically different.

The rectifiers used in this project were 3-junction devices of the HV series with regular (ie. not reduced by a special process) switching speed - described in terms of reverse recovery time of 600 ns, typically, measured in the Tektronix "S" circuit with $i_F = i_R = 2$ mA. The diode capacitance at 1 kHz and -100 V, measured using a Boonton RF Admittance Bridge Mod 33A, averages 0.77 pF and ranges from .65 to .85 pF. The leakage currents of these devices were below 10 nA @ 1000 V at room temperature.

To improve the operation at higher frequencies the devices should have a low reverse recovery time, low turn-on time and a low capacitance. It is important to keep the leakage currents low, although we did not see any difference in performance between multipliers made using rectifiers with maximum leakage currents of 10 nA at 1000V and those with leakages of the order of 2 - 3 nA.

We decided to try 6 new types of rectifiers and compare them with the HV series devices used previously. For this purpose, we assembled 10 multipliers, 2 each of every type of rectifiers, using the TSK 25 - 250 and TSK 25 - 251 rectangular capacitor banks.

The rectifiers were 3, and 2-junction devices from the following series:

| | | |
|---|---|---|
| HV | - | Regular switching speed |
| HX | - | low reverse recovery time |
| HXC | - | low reverse recovery time, low capacitance |
| HAC | - | low reverse recovery time, controlled avalanche, low capacitance |
| HSC | - | low reverse recovery time, fast turn-on, low capacitance |
| HFC | - | very low reverse recovery time, controlled avalanche, low capacitance |

Table 1 summarizes the electrical properties of the rectifiers belonging to these series.

The results of testing of the multipliers are given in Table 2. Measured were the output voltage, charging current and the input capacitance at different frequencies: 20 kHz, 30 kHz, and 40 kHz. One of the multipliers with HX 3 rectifiers was misassembled and taken out of the tests.

At 40 kHz distortions were observed in the input waveform which resulted in the output voltage readings exceeding in some cases 6000 V, yielding apparent efficiency values above 100%.

The problem is probably associated with the inadequate frequency response of the voltage amplifier providing the input signal to the multipliers and with the way of measuring this signal - on an r.m.s. meter with later conversion to peak - to - peak values.

The test circuit for the input capacitance and charging current is being examined to improve the accuracy and validity of measurements.

The following conclusions can be drawn from these tests:

1. Multipliers assembled with HV-type rectifiers show the highest input capacitance and charging currents which may exceed the specified 150 μA even at 20 kHz.
2. A slight improvement can be achieved with the use of HX-type devices. The capacitance still is very close to the limit and the charging current goes out of specification at 30 kHz.
3. A significant improvement is observed in the case of all multipliers made with low-capacitance rectifiers - the input capacitance is reduced below 4 pF and the charging currents all drop below 70 μA at 20 kHz and below 140 μA at 30 kHz. They are still marginally out of specification at 40 kHz. Device #68 was an exception, having higher charging currents.
4. Among the low capacitance rectifiers the HFC are the fastest, with HAC, HSC and HXC close together. However, the forward voltage drop of the HFC rectifiers is much higher and less reproducible.

A batch of 868 HSC - 3-junction rectifiers was manufactured to be used in the hybrid module version of the multipliers.

Since the reduction of the capacitance of the rectifiers is achieved by reducing the junction area, the devices are much more fragile and a serious problem is the breakage losses, already quite high in the HV series, because the devices are tested uncoated with epoxy.

From assembly through testing the yields for HSC - 3 series are between 25 and 80%, with an average of 46%.

The glass-epoxy substrates ordered outside and received on October 19, 1977 were to be used with the HSC series rectifiers, and 2 lots of substrate assemblies were potted - one of 12 rectangular and another of 6 curved.

Seven rectangular substrates were lost due to unbonding of the silver leads off the semiconductor chips. This was caused by two factors:

1. The weakness of the bond which is made with a thin layer of soft solder on the semiconductor chips. This bond is especially weak in the case of HSC series rectifiers since their area is 50% smaller than for HV series devices.
2. The nailheads of the rectifiers' leads were sticking above the top surface of the glass-epoxy substrates. The thickness of the substrate was typically .057" (ranging from .055" to .060"), as compared with the typical thickness of .064" - .068" for the substrates made at our model ship which were used previously.

The manufacturer of the substrates, Lazer-Tech. Ltd., Scarborough, Ont. was contacted and advised us that tightening of the tolerance on the substrate thickness to .064" - .068" would double or perhaps triple their material costs and would have to be done either by means of selection of the laminate sheets, or by ordering custom-made material.

Another approach could be to reduce the length of the rectifier body by about .010" changing from 3-junction devices to 2-junction. This would have the negative effects of decreased yields, increased junction capacitance and increased operating voltage per junction from 330 V to 500 V.

The important benefit of using 2-junction devices would be keeping low the multiplier thickness with which we had difficulties in meeting the specification.

Two batches of 2-junction rectifiers, HXC 2 - fast reverse recovery and HSC 2 - fast reverse recovery and turn-on were fabricated and tested. The basic characteristics of the devices are given in Table 1.

Yields obtained for the test batches of devices were low, mainly due to their fragility, 21% for HSC and 40% for HXC.

Multipliers were assembled using TSK 25 - 250 and TSK - 25 - 251 rectangular capacitor banks and discrete rectifiers. Two multipliers were started with each type of devices, however, only the devices with HSC 2 diodes were tested. Of the other pair, one was broken and the other misassembled. The results of electrical test of these multipliers are given in Table 2.

The main conclusions of this series of experiments are the following:

1. Small-area HXC 2-junction rectifiers have leakage currents and capacitances low enough to be acceptable in multipliers built to meet the requirements of this program at the operating frequency of 30 kHz.
2. The fast turn-on is an advantage for good high-frequency operation of HSC rectifiers. Due to higher manufacturing yields it seems, however, better to use HXC devices in future work.

Two production batches of 400 pcs. each of HXC 2 rectifiers were started and scrapped due to excessive breakage. The manufacturing process was adjusted to eliminate this problem and, in another 2 batches, 511 devices were manufactured with 64% yields. The capacitance of these devices was on average 0.28 pF at 1 MHz and -100 V.

Using HXC 2 devices and glass-epoxy substrates made by Lazer Tech. Ltd., 38 rectifier-substrate assemblies, 21 rectangular and 17 curved, were potted. Two curved assemblies were scrapped during later processing, one at lapping and one at lead-attaching.

## 2.3 Life - Testing Of Multipliers

Six multipliers, 2 rectangular and 4 curved, were put on life test under the following conditions:

- input voltage 1000 V p-p
- Load current 500 nA
- Temperature 50°C

The devices came from the lots fabricated in July and October 1977 for the Second Engineering Sample Submission.

The output voltages of the multipliers at the start of the test, after 24 hrs. and after 1000 hrs. of testing, are given in Table 3.

With the exception of device #8 all the others did not show any significant change of output voltage.

Device #8 was retained from the manufactured lot as suspected of sub-standard quality - since it was showing at tests high ripple voltage (52 V p-p, compared with the lot average of 17.4 V) and rather low efficiency of 90% (97.3% lot average).

The testing continues.

## 2.4 Production Jigs And Materials

The conditioning rings for the Lapmaster 12 machine were received on Oct. 7. With the lapping jigs fabricated in-house, we have the capability to lap at a time 72 rectangular or 45 curved rectifier-substrate assemblies.

On November 21, Dr. M. Korwin-Pawlowski visited the Erie Technological Products Inc. plant at Erie, Pa. and had a meeting with the engineering personnel involved in developing and manufacturing the capacitor banks used in this project. Problems relating to the increase of the breakdown voltage of the capacitors and the assurance of dimensions and pad layout were discussed. 300 curved capacitor banks TSK 25 - 260 were ordered to be delivered in January 1978.

## 2.5 Progress Review Meeting

On December 15-16, 1977 a Program Review Meeting was held at the Erie Technological Products of Canada plant in Trenton, Ontario.

Messrs. D. Biser, U.S. Army Electronics Command, H. Finkelstein and H. Kessler, Night Vision Laboratory, Ft. Belvoir were present from the U.S. Government side and Dr. M. Korwin-Pawlowski and Messrs. G. Gordon, B. McCallum and D. Platt were representing Erie Technological Products of Canada.

The current state of the program was discussed in the meeting and the plans for future work.

Electronic Command Industrial Preparedness Requirements No. 15 require the contractor to submit an updated specification for the multipliers with the last set of Engineering Samples. The update of the specification was discussed and a draft of the updated specification SCS 495 will be submitted by February 15, 1978.

## 3. CONCLUSIONS

The testing of the multipliers to the Second Engineering Sample requirements shows that the devices perform satisfactorily in terms of efficiency at no load and under load, at room, high (+50°C) and low (-54°C) temperatures.

Problems with the input capacitance, and charging current at the higher end of the frequency range will likely be corrected by optimizing the characteristics of rectifiers.

The multipliers are performing satisfactorily at life-testing.

## 4. PROGRAM FOR NEXT QUARTER

4.1 Fabricate and test to the Second Engineering Sample requirements of SCS - 495 with modifications discussed at the Program Review Meeting held at Trenton on December 16 - 19, 1977, 6 each, rectangular and curved multipliers with HXC 2 rectifiers.

4.2 Submit for evaluation and approval an updated specification SCS - 495.

5. PUBLICATIONS AND REPORTS

No reports or publications were made on the work associated with this program during the current quarter.

6. IDENTIFICATION OF PERSONNEL

Brief descriptions of the background of technical personnel involved were included in the preceding Quarterly Progress Reports.

During the Sixth quarter of the program the following persons worked in their area of responsibility:

| INDIVIDUAL | RESPONSIBILITY | HRS. SPENT |
|---|---|---|
| Dr. M. Korwin-Pawlowski | Program Manager | 115 |
| G. Gordon | Senior Electronic Engineer | 24 |
| D. Platt | Manager, Quality Assurance and Control, High Voltage Products | 80 |
| D. Archard | Senior Test Technician | 100 |
| V. Glenn | Q.C. Inspector | 32 |
| P. Maples | Senior Engineering Tech. | 2 |
| L. Macklin | Draftsman | 30 |
| | Manufacturing Personnel | 59 |

ELECTRICAL PROPERTIES OF RECTIFIERS

| Type | F.V.D. @ 10 mA (V) | | $i_R$ @ 1 kV (nA) | | $T_{RR}$ (ns) | | C (pF) | |
|---|---|---|---|---|---|---|---|---|
| | Average | Max. | Average | Max. | Average | Max. | Average | Max. |
| HV3 | 2.12 | 2.4 | 7.86 | 10 | 570 | 660 | 0.77 | .83 |
| HX3 | 2.97 | 3.5 | 6.65 | 10 | 198 | 260 | 0.95 | 1.14 |
| HAC3 | 3.65 | 4.0 | 1.63 | 2 | 174 | 180 | 0.22 | .30 |
| HSC3 | 3.32 | 4.0 | 0.94 | 2 | 128 | 140 | 0.17 | .21 |
| HFC3 | 10.86 | 12.0 | 0.78 | 2 | 62 | 70 | 0.20 | .24 |
| HXC2 | 2.53 | 2.85 | 0.90 | 2 | 185 | 200 | 0.19 | .24 |
| HSC2 | 1.90 | 2.35 | 0.61 | 2 | 165 | 190 | 0.23 | .25 |

Notes:

1. All measurements at 25°C
2. $T_{RR}$ - measured using Tektronix "S" circuit $i_F = i_R = 2$ mA
3. C - measured on Boonton RF Admittance Meter Model 33A at 1 MHz and -100 V.
4. Maximum F.V.D. and $i_R$ tested on 100% of lot
5. Maximum $T_{RR}$ and C in the tested sample of 20 pcs.

TABLE 1

## EVALUATION OF MULTIPLIERS WITH RECTIFIERS OF VARIOUS TYPES

| # | Rectifier Type | Condition "A" @ f = 20 kHz | | | Condition "B" @ f = 30 kHz | | | Condition "C" @ f = 40 kHz | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Vo (kV) | $i_c$ (μA) | $C_i$ (pF) | Vo (kV) | $i_c$ (μA) | $C_i$ (pF) | Vo (kV) | $i_c$ (μA) | $C_i$ (pF) |
| | | @1kV p - p | @1kV p - p | @500 Vp-p | @1kV p - p | @1kV p - p | @ 500 Vp-p | @1kV p - p | @1kV p - p | @ 500 Vp-p |
| 59 | HV3 | 5.77 | 240<br>200 | 9.12 | 5.76 | 380<br>340 | 9.16 | 5.81 | 600<br>560 | 9.36 |
| 60 | HV3 | 5.74 | 120<br>120 | 9.39 | 5.72 | 380<br>390 | 9.46 | 5.80 | 660<br>680 | 9.63 |
| 61 | HX3 | 5.81 | 140<br>150 | 7.69 | 5.80 | 160<br>180 | 7.67 | 5.92 | 510<br>460 | 7.77 |
| 62 | HAC3 | 5.99 | 70<br>65 | 3.66 | 5.99 | 120<br>140 | 3.72 | 6.05 | 210<br>220 | 3.78 |
| 63 | HAC3 | 6.00 | 66<br>66 | 3.56 | 5.99 | 120<br>125 | 3.60 | 6.08 | 220<br>200 | 3.64 |
| 64 | HSC3 | 5.98 | 64<br>68 | 3.10 | 5.98 | 110<br>115 | 3.10 | 6.02 | 180<br>185 | 3.18 |
| 65 | HSC3 | 5.99 | 62<br>72 | 3.19 | 5.98 | 110<br>120 | 3.21 | 6.02 | 175<br>195 | 3.29 |
| 66 | HFC3 | 5.99 | 58<br>58 | 3.52 | 5.98 | 95<br>100 | 3.55 | 6.01 | 170<br>175 | 3.62 |
| 67 | HFC3 | 5.99 | 52<br>56 | 3.45 | 5.99 | 90<br>100 | 3.48 | 6.05 | 160<br>170 | 3.55 |
| 68 | HSC2 | 5.98 | 135<br>110 | 3.23 | 5.97 | 140<br>170 | 3.24 | 6.02 | 180<br>280 | 3.30 |
| 69 | HSC2 | 5.99 | 52<br>54 | 3.53 | 5.92 | 95<br>95 | 3.56 | 6.03 | 170<br>170 | 3.66 |

TABLE 2

OUTPUT VOLTAGE OF MULTIPLIERS ON LIFE-TEST

$V_i$ = 1000 Vp-p, $i_L$ = 500 nA, T= 50 ° C

| Unit # | Type | Vo (kV) | | |
|---|---|---|---|---|
| | | 0 hrs. | 24 hrs. | 1000 hrs. |
| 57 | Rectangular | 5.70 | 5.70 | 5.70 |
| 65 | " | 5.70 | 5.70 | 5.70 |
| 7 | Curved | 5.75 | 5.75 | 5.75 |
| 8 | " | 5.35 | 4.40 | 4.30 |
| 9 | " | 5.75 | 5.75 | 5.75 |
| 18 | " | 5.75 | 5.75 | 5.75 |

Table 3

## APPENDIX A

## REPORT ON SECOND ENGINEERING SAMPLES

# ERIE TECHNOLOGICAL PRODUCTS

OF CANADA, LIMITED



## REPORT ON SECOND ENGINEERING SAMPLES

Erie Technical Report No. 0019

Performed by: Erie Tech. Prod. of Can. Ltd.
Authorized by: Procurement & Production Directorate
USAECOM Fort Monmouth, N.J.
Contract No.: DAAB07-76-C-0041
Ref.: High Voltage Hybrid Multiplier Modules

| TEST AND DEMONSTRATION REPORT PERTAINING TO SECOND ENGINEERING SAMPLES | | | |
|---|---|---|---|
| Item: | Name and Title: | Signature: | Date: |
| Test Initiated: | N/A | N/A | 26 Sept/77 |
| Test Completed: | N/A | N/A | 20 Oct./77 |
| Prepared By: | Douglas A. Platt, Q.C./Q.A. Mgr., H. V. Products, Erie Tech. | Platt (QC Insp ERIE 20) | 21 Oct./77 |
| Test Technician: | Dennis G. Archard, Q.C. Tech., H. V. Products, Erie Tech. | D. Archard (QC Insp ERIE 07) | 21/OCT/77 |
| Program Manager: | Dr. M. L. Korwin-Pawlowski, Eng. Mgr., Semiconductor Devices, Erie Tech. | M Pawlowski | 21/Oct/77 |
| Final Release: | N/A | N/A | 21 Oct./77 |

Report Distribution:

2 c.c. to: Director, Night Vision Laboratory
Systems Development Technical Area
ATTN: DRSEL-NV-SD (Mr. H. Finkelstein)
Fort Belvoir, Va. 22060

1 c.c. to: Commander, U.S. Army Electronics Command
ATTN: DRSEL-PP-I-PI-1 (Mr. D. Biser)
Fort Monmouth, N.J. 07703

5 FRASER AVENUE, TRENTON, ONTARIO, CANADA
PHONE: (613) 392-2581 • TELEX: 06-62279
K8V 5S1

| REPORT SUMMARY SHEET: | 2. System: Night Vision | Action: | Day | Mo. | Yr. |
|---|---|---|---|---|---|
| 1. Part Name: High Voltage Hybrid Mult. Modules | 5. Report No.: ETR 0019 | Test Compl. | 20 | Oct. | 77 |
| | | Report Compl. | 21 | Oct. | 77 |
| 4. Report Title: Erie Technical Report | 6. Test Type: Electrical Testing of the Second Engineering Samples | | | | |

7. This test (supersedes) (supplements) Report No.: No Previous Issue

| 8. Type: | 8A. Part Description: | 9. Vendor | 10. Vendor Part No.: | 11. Gov. No.: | 12. Total Tested: |
|---|---|---|---|---|---|
| I | Rectangular Multiplier Module | Erie | TSK 312-000 | N/A | 17 |
| II | Curved Multiplier Module | Erie | TSK 313-000 | N/A | 14 |

| 13. | Internal Specs. Etc.: | 14. Mil. Spec. Reference | |
|---|---|---|---|
| A. | Fort Monmouth Contract No. DAAB07-76-C-0041 | D. | Mil.-Std.-202 |
| B. | USAECOM MM & T Requirement No. 15, December, 75 | E. | Mil.-Std.-831 |
| C. | USAECOM Technical Requirement No. SCS-495, 19 Nov. 75 | | |

| 15. Item: | Test or Environment: | Spec. SCS-495 Para.: | Test Details: | Mult. Type: I No. Test: | Mult. Type: I No. Rej.: | Mult. Type: II No. Test: | Mult. Type: II No. Rej.: |
|---|---|---|---|---|---|---|---|
| 1. | O/P Voltage (no load) | 3.2.1 | Pre environmental (R.T.) | 17 | 0 | 14 | 0 |
| 2. | Ripple Voltage | 3.2.1.4 | Pre environmental (R.T.) | 17 | 0 | 14 | 1 |
| 3. | Charge Current | 3.2.1.3 | Pre environmental (R.T.) | 17 | *17 | 13 | *13 |
| 4. | Input Capacitance | 3.2.1.2 | Pre environmental (R.T.) | 17 | * 5 | 13 | *13 |
| 5. | O/P Voltage (full load) | 3.2.1 | Pre environmental (R.T.) | 17 | 0 | 13 | 1 |
| 6. | Efficiency Cal. | 3.2.1.1 | Pre environmental (R.T.) | 17 | 0 | 12 | 0 |
| 7. | O/P Voltage (no load) | 3.2.4.1 | High temp. (+50°C) | 3 | 0 | 2 | 0 |
| 8. | Ripple Voltage | 3.2.4.1.4 | High temp. (+50°C) | 3 | 0 | 2 | 0 |
| 9. | Charge Current | 3.2.4.1.3 | High temp. (+50°C) | 3 | * 2 | 2 | * 2 |
| 10. | Input Capacitance | 3.2.4.1.2 | High temp. (+50°C) | 3 | * 2 | 2 | * 2 |
| 11. | O/P Voltage (full load) | 3.2.4.1.1 | High temp. (+50°C) | 17 | 0 | 12 | 0 |
| 12. | O/P Voltage (no load) | 3.2.4.2 | Low temp. (-54°C) | 3 | 0 | 2 | 0 |
| 13. | Ripple Voltage | 3.2.5.2.4 | Low temp. (-54°C) | 3 | 0 | 2 | 0 |
| 14. | Charge Current | 3.2.4.2.3 | Low temp. (-54°C) | 3 | * 3 | 2 | * 2 |
| 15. | Input capacitance | 3.2.4.2.2 | Low temp. (-54°C) | 3 | * 1 | 2 | * 1 |
| 16. | O/P Voltage (full load) | 3.2.4.2.1 | Low temp. (-54°C) | 17 | 0 | 12 | 0 |
| 17. | Thermal Shock | 3.2.4.3.1 | 25 cycles (-65 to +71°C) | 17 | N/A | 12 | N/A |
| 18. | High Temp. Storage | 3.2.4.3.2 | 8 hrs. @ +71°C | 17 | N/A | 12 | N/A |
| 19. | O/P Voltage (no load) | 3.2.1 | Post environmental (R.T.) | 17 | 0 | 12 | 0 |
| 20. | Ripple Voltage | 3.2.1.4 | Post environmental (R.T.) | 17 | 0 | 12 | 0 |
| 21. | Charge Current | 3.2.1.3 | Post environmental (R.T.) | 17 | *17 | 12 | *12 |
| 22. | Input Capacitance | 3.2.1.2 | Post environmental (R.T.) | 17 | * 3 | 12 | *12 |
| 23. | O/P Voltage (full load) | 3.2.1 | Post environmental (R.T.) | 17 | 0 | 12 | 0 |
| 24. | Efficiency Cal. | 3.2.1.1 | Post environmental (R.T.) | 17 | 0 | 12 | 0 |

16. Summary of Report: See "Test Report Summation" Page 10

| 17. Tested Beyond Spec. ☐ Yes | 18. Vendor Informed: Letter ☐ Rep't ☐ Oral ☐ | 19. Signed: | 20. Contractor: | Subcontractor: |
|---|---|---|---|---|



*NOTE: Refer to the applicable "Test Evaluation and Results" Paragraph contained in the body of this report.

## 3.0) Table of Contents:

4.0) Report Description:

This test and demonstration report (data item B002) pertains to the electrical and environmental evaluation of two "Six Stage High Voltage Multiplier Module" types, supplied as Second Engineering Samples against "Manufacturing Methods and Technology Contract DAAB07-76-C-0041."

The test specimens were tested in accordance with the applicable paragraphs of "Electronics Command Technical Requirement SCS-495, dated 19 Nov./75." The requirements contained in the forementioned document are considered as design goals and subject to change prior to the next submission of Confirmatory Samples. Devices that are marginal failures have not been removed from the sample and their test results are contained in this report.

5.0) Test Sample Description:

The test samples are individually identified by means of an identification no. (label) which is attached to the multiplier ground leads.

Multiplier "hook-up" lead identification:

a) The "ground lead" (ribbon type) is jointly terminated with the cylindrical "$D_1$" lead
b) The "A.C. input" is the remaining ribbon lead
c) The "D.C. output" is the remaining cylindrical lead.

NOTE: All operational test were conducted with the test specimen totally immersed in Fluorinert "FC-43" (mfg. by 3M Co.).

5.1) Disposition of Test Specimens:

5.1.1) Sixteen (16) type I Rectangular Multiplier Modules (TSK 312-000, ident. no's.: 32, 34, 35, 36, 39, 41, 42, 43, 44, 46, 48, 49, 51, 52, 56, 58) are being submitted as Second Engineering Samples (item no. 0001AA) against MM & T contract.

5.1.2) Eight (8) type II Curved Multiplier Modules (TSK 313-000, ident. no's.: 5, 6, 10, 11, 12, 13, 14, 16) are being submitted as Second Engineering Samples (item no. 0001AA) against MM & T contract.

5.1.3) The remaining multipliers are being held by Erie for additional evaluation.

6.0) Test and Evaluation Results:

6.1) Pre Environmental Electrical Testing (Room Temp.)

6.1.1) Output Voltage (No Load)

Ref.: Appendix I & II, Sheet 1, Cond. A
Test Circuit Fig. 1, Fig. 5

Method: With 1000 Vp/p @ 30 KHz applied, record the output voltage

Results: The 31 multipliers successfully conform to the expected output voltage level.

6.1.2) Ripple Voltage

Ref.: Appendix I & II, Sheet 1, Cond. B
Test Circuit Fig. 3, Fig. 5

Method: With 1000 Vp/p @ 30 KHz applied, record the output ripple voltage using a "Jennings Type" scope probe

Results: 1 unit (# 15) was rejected and removed from the sample for exhibiting excessive ripple (260 Vp/p). The remaining 30 multipliers successfully conform to the $<3\%$ requirement of SCS-495, Para 3.2.1.4.

6.1.3) Charge Current

Ref.: Appendix I & II, Sheet 1, Cond. C
Test Circuit Fig. 4, Fig. 5

Method: With 1000 Vp/p @ 30 KHz applied, record the charging current

Results: All 30 multipliers failed to conform to the $< 150\ \mu A$ requirement of SCS-495, Para 3.2.1.3

6.1.4) Input Capacitance

Ref.: Appendix I & II, Sheet 1, Cond. D
Test Circuit Fig. 4, Fig. 5

Method: With 500 Vp/p @ 30 KHz applied, record the input capacitance reading on the variable capacitor

Results: 18 multipliers failed to conform to the $< 8$ pF requirement of SCS-495, Para 3.2.1.2.

6.1.5) Output Voltage (Full Load)

Ref.: Appendix I & II, Sheet 1, Cond. E
Test Circuit Fig. 2, Fig. 5

Method: With 1000 Vp/p @ 30 KHz applied, record the output voltage

Results: 1 unit (# 17) was removed from the sample for exhibiting a lower than normal output voltage. The remaining 29 multipliers successfully conform to the expected output voltage level.

6.1.6) Efficiency Calculation

Ref.: Appendix I & II, Sheet 1, Cond. F
Test Circuit Fig. 1, Fig. 2, Fig. 5

Method: Using the formula provided in Para 6.3.1 of SCS-495 the calculated multiplier efficiencies, with the output at full load (worse case), exceed the 85% requirement of SCS-495, Para 3.2.1.1.

## 6.2) High Temperature Electrical Testing

NOTE: Twenty-nine (29) multipliers were tested for output voltage (full load) at high temperature but because of test limitations only five (5) were examined for output voltage (no load), ripple voltage, charge current, and input capacitance.

6.2.1) Output Voltage (No Load)

Ref.: Appendix I & II, Sheet 2, Column 1
Test Circuit Fig. 1, Fig. 5

Method: With the five multipliers mounted in a temperature chamber at + 50°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the output voltage.

Results: The 5 multipliers successfully conform to the expected output voltage level.

6.2.2) Ripple Voltage

Ref.: Appendix I & II, Sheet 2, Column 2
Test Circuit Fig. 3, Fig. 5

Method: With the five multipliers mounted in a temperature chamber at + 50°C with an input voltage of 1000 Vp/p @ 30 KHz. applied, record the output ripple voltage

Results: The 5 multipliers successfully conform to the $<3\%$ requirement of SCS-495, Para 3.2.4.1.4.

6.2.3) Charge Current

Ref.: Appendix I & II, Sheet 2, Column 3
Test Circuit Fig. 4, Fig. 5

Method: With the five multipliers mounted in a temperature chamber at + 50°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the charge current

Results: Four of the five units failed to conform to the $< 300\ \mu A$ requirement of SCS-495, Para 3.2.4.1.3

6.2.4) Input Capacitance

Ref.: Appendix I & II, Sheet 2, Column 4
Test Circuit Fig. 4, Fig. 5

Method: With the five multipliers mounted in a temperature chamber at + 50°C with an input voltage of 500 Vp/p @ 30 KHz applied, record the input capacitance.

Results: Four of the five units failed to conform to the <8 pF requirement of SCS-495, Para 3.2.4.1.2.

6.2.3) Output Voltage (Full Load)

Ref.: Appendix I & II, Sheet 2, Column 5
Test Circuit Fig. 2, Fig. 5

Method: With all 29 multipliers mounted in a temperature chamber at + 50°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the output voltage and calculate the efficiency.

Results: The multipliers exceed the 80% efficiency requirement of SCS-495, Para 3.2.4.1.1.

6.3) Low Temperature Electrical Testing

NOTE: Twenty-nine (29) multipliers were tested for output voltage (full load) at low temperature but because of test limitations only five (5) were examined for output voltage (no load), ripple voltage, charge current, and input capacitance.

6.3.1) Output Voltage (No Load)

Ref.: Appendix I & II, Sheet 2, Column 6
Test Circuit Fig. 1, Fig. 5

Method: With the five multipliers mounted in a temperature chamber at - 54°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the output voltage.

Results: The 5 multipliers successfully conform to the expected output voltage level.

6.3.2) Ripple Voltage

Ref.: Appendix I & II, Sheet 2, Column 7
Test Circuit Fig. 3, Fig. 5

Method: With the five multipliers mounted in a temperature chamber at - 54°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the output ripple voltage.

Results: The 5 multipliers successfully conform the the < 3% requirement of SCS-495, Para 3.2.5.2.4.

6.3.3) Charge Current

Ref.: Appendix I & II, Sheet 2, Column 8
Test Circuit Fig. 4, Fig. 5

Method: With all five multipliers mounted in a temperature chamber at - 54°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the charge current.
Results: All five units failed to conform to the < 150 μA requirement of SCS-495, Para 3.2.4.2.3.

6.3.4) Input Capacitance

Ref.: Appendix I & II, Sheet 2, Column 9
Test Circuit Fig. 4, Fig. 5
Method: With the five multipliers mounted in a temperature chamber at - 54°C with an input voltage of 500 Vp/p @ 30 KHz applied, record the input capacitance.
Results: Two of the five units failed to conform to the < 8 pF requirement of SCS-495, Para 3.2.4.2.2.

6.3.5) Output Voltage (Full Load)

Ref.: Appendix I & II, Sheet 2, Column 10
Test Circuit Fig. 2, Fig. 5
Method: With all 29 multipliers mounted in a temperature chamber at - 54°C with an input voltage of 1000 Vp/p @ 30 KHz applied, record the output voltage and calculate the efficiency.
Results: The multipliers exceed the 80% efficiency requirement of SCS-495, Para 3.2.4.2.1.

6.4) <u>Thermal Shock Evaluation</u> (Non-Operational)

Ref.: Appendix I & II, Sheet 2, Column 11
Method: The twenty-nine (29) multipliers were tested in accordance with test cond. B-1, Method 107D, of Mil. Std. 202,only the high temperature extreme was reduced to +71°C, per Para 3.2.4.3.1 of SCS-495.
Results: See Post Environmental Electrical Test Results.

6.5) <u>High Temperature Storage</u> (Non-Operational)

Ref.: Appendix I & II, Sheet 2, Column 12
Method: The twenty-nine (29) multipliers were subjected to 8 hours storage at + 71°C per Para 3.2.4.3.2 of SCS-495.
Results: See Post Environmental Electrical Test Results.

6.6) <u>Post Environmental Electrical Testing</u> (Room Temp.)

6.6.1) Output Voltage (No Load)

Ref.: Appendix I & II, Sheet 3, Cond. A

| | |
|---|---|
| | Test Circuit Fig. 1, Fig. 5 |
| Method: | With 1000 V p/p @ 30 KHz applied, record the output voltage |
| Results: | The 29 multipliers successfully conform to the expected output voltage level. |

6.6.2) Ripple Voltage

| | |
|---|---|
| Ref.: | Appendix I & II, Sheet 3, Cond. B<br>Test Circuit Fig. 3, Fig. 5 |
| Method: | With 1000 V p/p @ 30 KHz applied, record the output ripple voltage by using a "Jennings Type" scope probe. |
| Results: | The 29 multipliers successfully conform to the $< 3\%$ requirement of SCS-495 Para 3.2.1.4. |

6.6.3) Charge Current

| | |
|---|---|
| Ref.: | Appendix I & II, Sheet 3, Cond. C<br>Test Circuit Fig. 4, Fig. 5 |
| Method: | With 1000 Vp/p @ 30 KHz applied, record the charging current |
| Results: | All 29 multipliers failed to conform to the $< 150\ \mu A$ requirement of SCS-495, Para 3.2.1.3. |

6.6.4) Input Capacitance

| | |
|---|---|
| Ref.: | Appendix I & II, Sheet 3, Cond. D<br>Test Circuit Fig. 4, Fig. 5 |
| Method: | With 500 Vp/p @ 30 KHz applied, record the input capacitance reading on the variable capacitor. |
| Results: | 15 multipliers failed to conform to the $< 8$ pF requirement of SCS-495, Para 3.2.1.2. |

6.6.5) Output Voltage

| | |
|---|---|
| Ref.: | Appendix I & II, Sheet 3, Cond. E<br>Test Circuit Fig. 2, Fig. 5 |
| Method: | With 1000 Vp/p @ 30 KHz applied, record the output voltage |
| Results: | The 29 multipliers successfully conform to the expected output voltage level. |

6.6.6) Efficiency Calculation

| | |
|---|---|
| Ref.: | Appendix I & II, Sheet 3, Cond F<br>Test Circuit Fig. 1, Fig. 2, Fig. 5 |

Method: Using the formula provided in Para 6.3.1 of SCS-495 the calculated multiplier efficiencies, with the output at full load (worse case), exceed the 85% requirement of SCS-495, Para 3.2.1.1.

7.0) Report Summation:

In this report we evaluated thirty-one (31) Second Engineering Multiplier Samples per MM & T contract DAAB07-76-C-0041. The results indicated by the various test paragraphs conclude that none of the multipliers examined conform to "all" the electrical requirements as specified in the applicable paragraphs of SCS-495.

7.1) Two (2) Type II multipliers (# 15, 17) exhibited an electrical flaw during initial testing and are to be considered manufacturing defects.

7.2) The high "charge current" readings are related to the increase in the input voltage frequency to 30 KHz. (NOTE: Previous tests were conducted at 20 KHz.) The present multiplier design is greatly effected by a test frequency change -

Example @ 20 KHz typical chg. current at R.T. = 140 μA
@ 30 KHz typical chg. current at R.T. = 260 μA
@ 40 KHz typical chg. current at R.T. = 500 μA

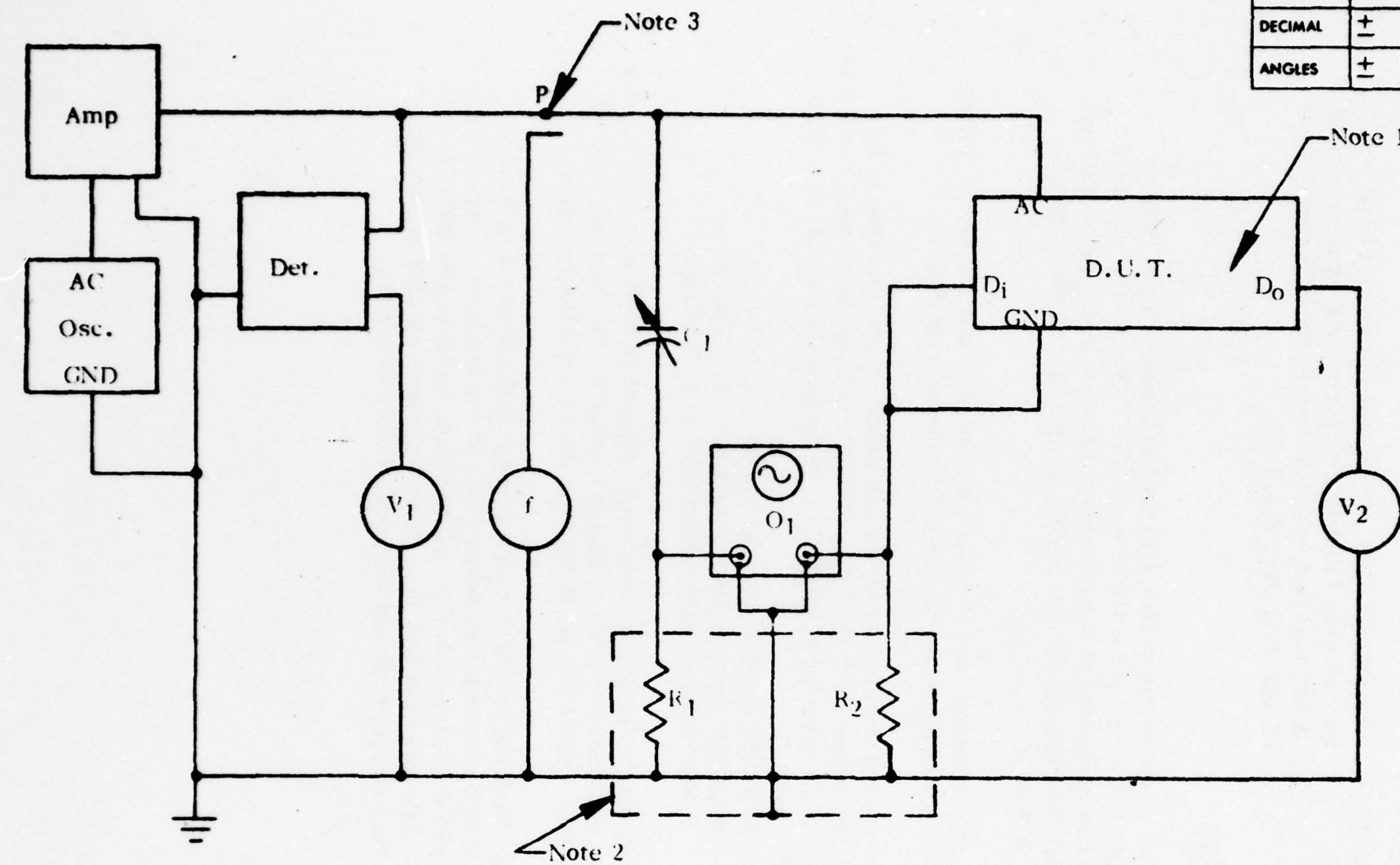
To conform to the total input frequency range of 20 to 40 KHz will require additional evaluation of other multiplier designs. Further information covering this subject will be included in the next quarterly report.

7.3) The high "input capacitance" readings are, in the writer's opinion, related to test circuit inadequaties. Due to the low level of capacitance (7 to 10 pF) it is extremely difficult to obtain accurate and stable test results. Erie requests that Fort Belvoir perform similar capacitance test to check both correlation and repeatability of results.

Figure 1

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES - DO NOT SCALE THIS DWG.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | |
| --- | --- |
| FRACTIONS | ± |
| DECIMAL | ± |
| ANGLES | ± |




TEST CIRCUIT
for
"No Load"
OUTPUT VOLTAGE EFFICIENCY EVALUATION

| | | |
| --- | --- | --- |
| DRAWN BY | LARRY MACKLIN | MATERIAL |
| CHECKED BY | [signature] | FINISH |
| DATE | 11/OCT/77 | |
| ERIE TECHNOLOGICAL PRODUCTS OF CANADA LTD TRENTON, ONTARIO | | Figure 1 |

REV. NO
REVISIONS

Figure 2

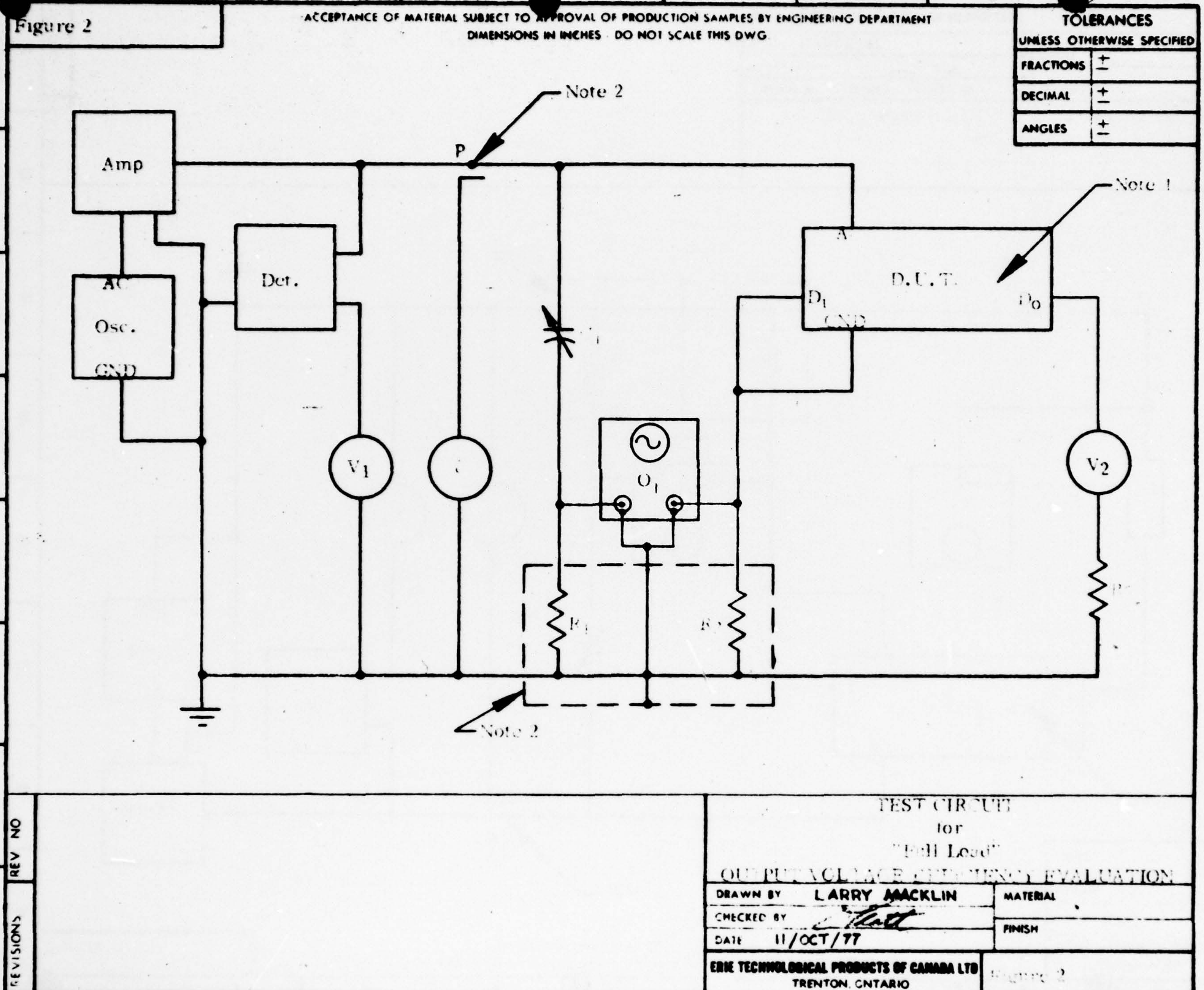
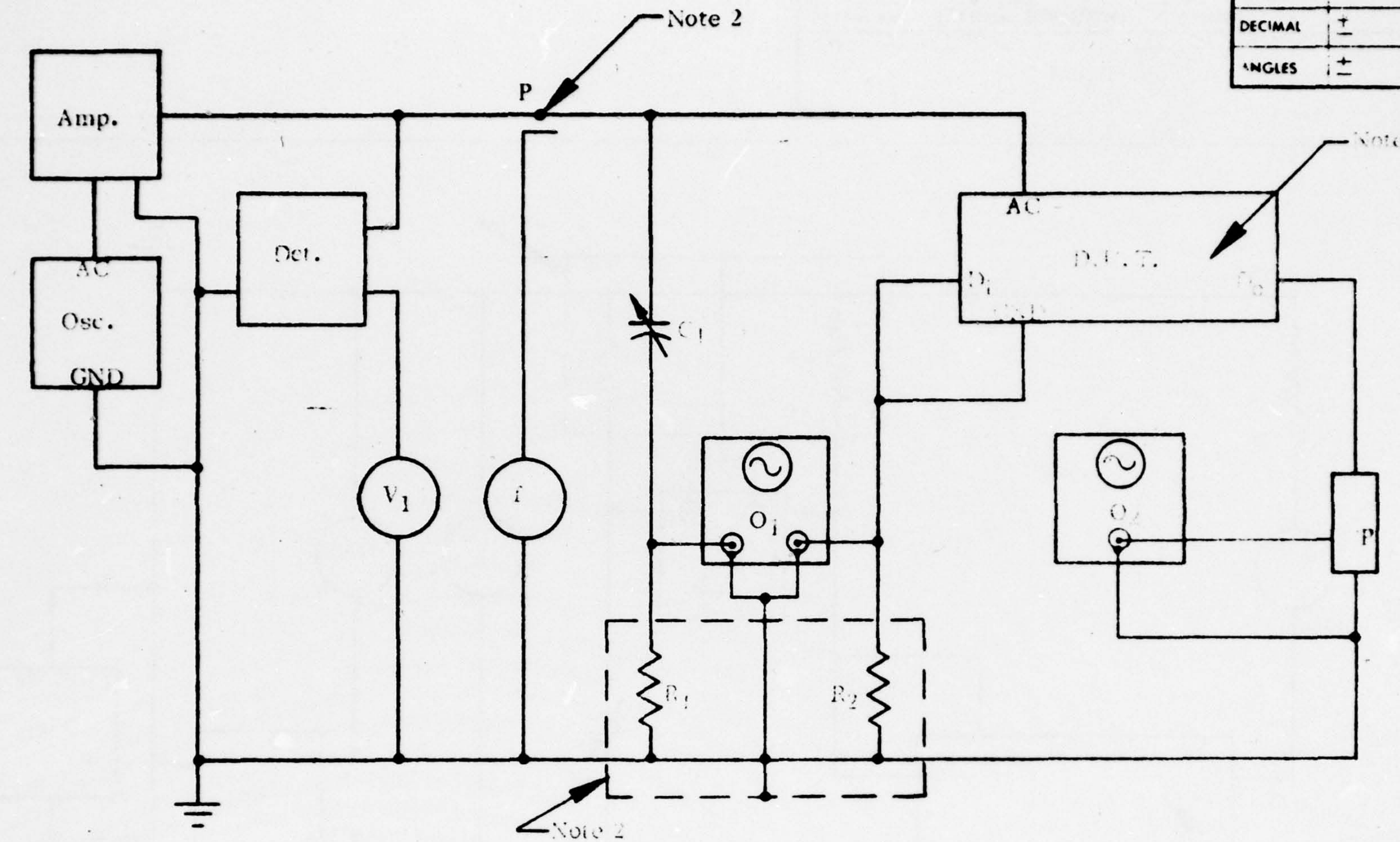

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES · DO NOT SCALE THIS DWG
TOLERANCES
UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
DECIMAL ±
ANGLES ±
Note 2
P
Amp
AC
Osc.
GND
Det.
V1
D.U.T.
A
D1
GND
Do
Note 1
O1
V2
R1
Note 2
REV NO
REVISIONS
TEST CIRCUIT
for
EVALUATION
DRAWN BY LARRY MACKLIN
CHECKED BY
DATE 11/OCT/77
MATERIAL
FINISH
ERIE TECHNOLOGICAL PRODUCTS OF CANADA LTD
TRENTON, ONTARIO

Figure 3

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES - DO NOT SCALE THIS DWG.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | |
|---|---|
| FRACTIONS | ± |
| DECIMAL | ± |
| ANGLES | ± |




TEST CIRCUIT
for
OUTPUT RIPPLE VOLTAGE EVALUATION

| | | | |
|---|---|---|---|
| DRAWN BY | LARRY MACKLIN | MATERIAL | |
| CHECKED BY | [signature] | FINISH | |
| DATE | 11/OCT/77 | | |

ERIE TECHNOLOGICAL PRODUCTS OF CANADA LTD
TRENTON, ONTARIO

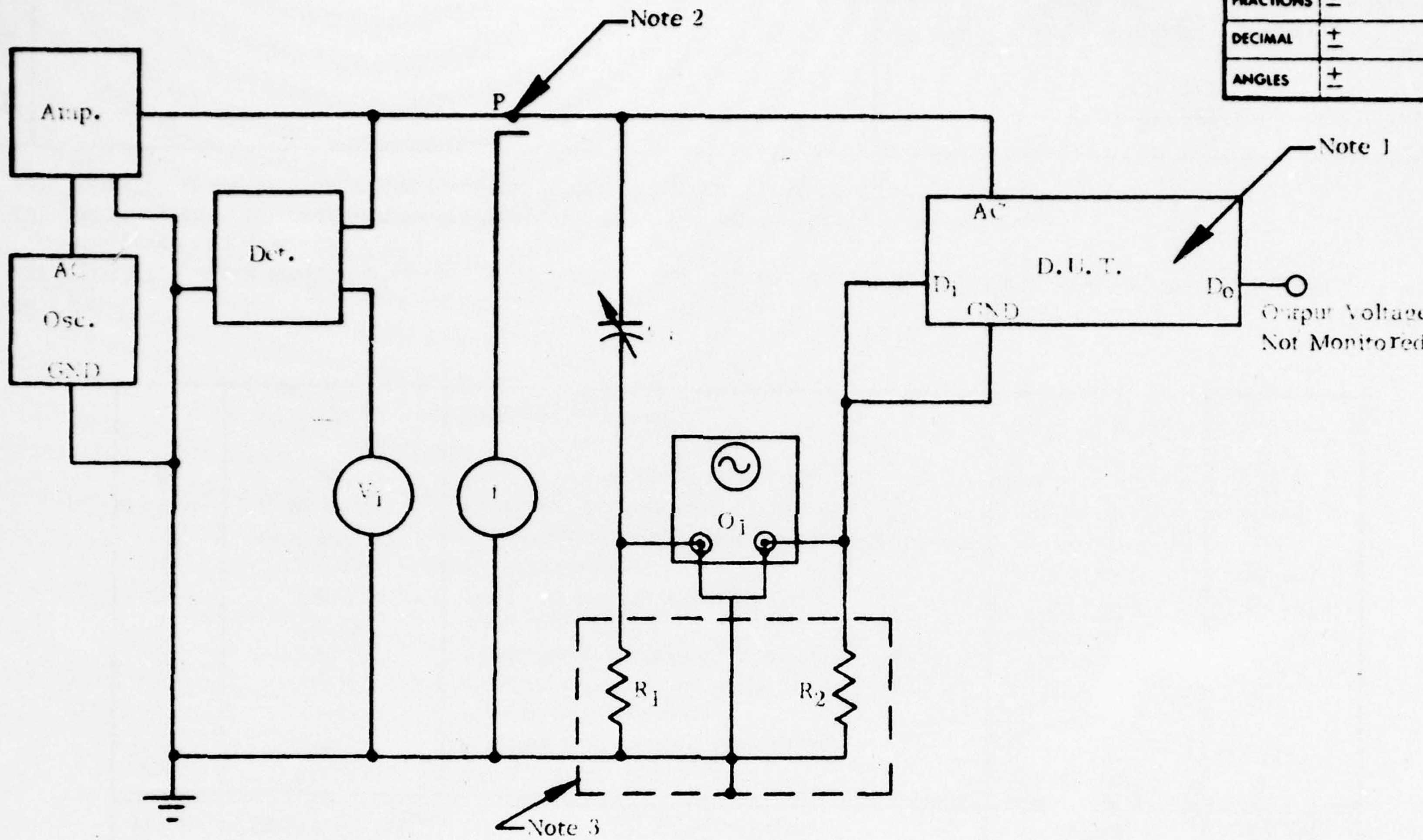
Figure 3

REV. NO
REVISIONS

Figure 4

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES - DO NOT SCALE THIS DWG.

| TOLERANCES UNLESS OTHERWISE SPECIFIED | |
|---|---|
| FRACTIONS | ± |
| DECIMAL | ± |
| ANGLES | ± |




TEST CIRCUIT
for
INPUT CAPACITANCE
AND CHARGE CURRENT EVALUATION

| | | | |
|---|---|---|---|
| DRAWN BY | LARRY MACKLIN | MATERIAL | |
| CHECKED BY | [signature] | FINISH | |
| DATE | 11/OCT/77 | | |

ERIE TECHNOLOGICAL PRODUCTS OF CANADA LTD
TRENTON, ONTARIO

Figure 4

REVISIONS | REV NO

1 2 3 4 5 6 7 8 9

Figure 5

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES · DO NOT SCALE THIS DWG.

| TOLERANCES | |
|---|---|
| UNLESS OTHERWISE SPECIFIED | |
| FRACTIONS | ± |
| DECIMAL | ± |
| ANGLES | ± |

# TEST EQUIPMENT LISTING

| REF. | CONTROL NO. | DESCRIPTION | MFG. | MODEL |
|---|---|---|---|---|
| Amp. | AM193 | AC Amplifier (Power Source) | Hewlett Packard | 25IT |
| Osc. | FPD72 | Oscillator (Function Generator) | Hewlett Packard | 3310A |
| Det. | ----- | Peak to Peak Detector | Erie | ---- |
| $V_1$ | VM041 | Electrostatic Voltmeter (0 to 2000 Vdc) | Beckman | LVE |
| $V_2$ | VM031 | Electrostatic Kilovoltmeter (0 to 15 KVdc) | Hallmark | KVE |
| f | FM004 | Electronic Counter | Hewlett Packard | 5321A |
| $O_1$ | AM166 | Dual Channel Oscilloscope | Tektronix | 536(T)(CA) |
| $O_2$ | AM305 | Oscilloscope | Tektronix | 545(H) |
| CP | TEX 105-300 | Capacitance Probe for Ripple Measurement | Erie | ---- |
| $R_1$ & $R_2$ | $R_1$ & $R_2$ | Precision Resistors (1 K ohm ± 0.01%) | General Radio | 1440 |
| $R_3$ | $R_3$ | Load Resistor (10 G ohm ± 10%) | Resistance Prod. Corp. | EBA |
| $C_1$ | CM004 | Variable Capacitor | General Radio | 1422 CC |

NOTES:

(1) "D. U. T." is the device under test, which in this case will be either TSK 312-000 or TSK 313-000 multipliers, immersed in FC-43.

(2) Shielding and coax cable connected to ground with all leads as short as possible.

(3) Point "P" is the location of the proximity electromagnetic coupling of the electronic (frequency) counter.

REV. NO

REVISIONS

TEST EQUIPMENT LISTING

| | | | |
|---|---|---|---|
| DRAWN BY | LARRY MACKLIN | MATERIAL | |
| CHECKED BY | [signature] | FINISH | |
| DATE | 11/OCT/77 | | |
| ERIE TECHNOLOGICAL PRODUCTS OF CANADA LTD TRENTON, ONTARIO | | Figure 5 | |

A B C D E F G H

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Test #

# ERIE TECHNOLOGICAL PRODUCTS
OF CANADA, LTD.

SHEET # 1 OF 3
NOTES # APPENDIX I
P.O. 17SR70A87549
F.O. 2543101
QTY. 17 pcs.

## QUALITY CONTROL DEP'T. - RECORDED DATA SHEET
FILE NO. ETR.0019

TEST Electrical Evaluation (PRE ENVIRONMENTAL)
PART TSK 312-000 (6 stage rectangular mult. module)
SPECIAL DETAILS Re.: Fort Monmouth Specification SCS-495

Start Date 23 Sept./77
Finish Date 26 Sept./77
Tested By D.A.
Approved By QC Insp ERIE 20

| TEST DATE | | | | | | |
|---|---|---|---|---|---|---|
| TEST COND. | "A" | "B" | "C" | "D" | "E" | "A - E" |
| INPUT VOLT. | 1000 V pk to pk | 1000 V pk to pk | 1000 V pk to pk | 500 V pk to pk | 1000 V pk to pk | 1000 V pk to pk |
| TEST FREQ. | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz |
| LOAD CURRENT | < 2 nA | < 2 nA | | | 500 nA | to 500 nA |
| PARAMETER | OUTPUT VOLTAGE | RIPPLE VOLTAGE | CHARGE CURRENT | INPUT CAPACITANCE | OUTPUT VOLTAGE | CAL. EFFICIENCY |
| UNITS | Vdc | Vp/p | µA | pF | Vdc | % |
| REQUIREMENT | Para 3.2.1 | Para 3.2.1.4 <3% p/p | Para 3.2.1.3 <150 µA | Para 3.2.1.2 < 8 pF | Para 3.2.1 | Para 3.2.1.1 85% minimum |
| No. 32 | 5860 | 35.1 | 250 ✓ | 7.88 | 5820 | 97.0 |
| 34 | 5820 | 31.2 | 250 ✓ | 7.67 | 5800 | 96.6 |
| 35 | 5860 | 29.9 | 260 ✓ | 7.84 | 5810 | 96.6 |
| 36 | 5850 | 29.9 | 255 ✓ | 7.88 | 5800 | 96.6 |
| 39 | 5800 | 33.8 | 260 ✓ | 7.88 | 5790 | 96.5 |
| 41 | 5810 | 33.8 | 265 ✓ | 7.97 | 5800 | 96.6 |
| 42 | 5820 | 33.8 | 255 ✓ | 7.15 | 5800 | 96.6 |
| 43 | 5820 | 29.9 | 255 ✓ | 8.30 ✓ | 5800 | 96.6 |
| 44 | 5810 | 31.2 | 250 ✓ | 7.77 | 5800 | 96.6 |
| 46 | 5810 | 39.0 | 260 ✓ | 8.10 ✓ | 5800 | 96.6 |
| 48 | 5840 | 24.7 | 255 ✓ | 8.25 ✓ | 5810 | 96.8 |
| 49 | 5820 | 29.7 | 260 ✓ | 8.00 | 5800 | 96.6 |
| 51 | 5840 | 33.8 | 255 ✓ | 8.03 ✓ | 5810 | 96.8 |
| 52 | 5860 | 33.8 | 255 ✓ | 7.97 | 5820 | 97.0 |
| 56 | 5850 | 32.5 | 260 ✓ | 7.71 | 5810 | 96.8 |
| 57 | 5820 | 33.8 | 260 ✓ | 8.19 ✓ | 5800 | 96.6 |
| 58 | 5810 | 32.5 | 255 ✓ | 7.92 | 5800 | 96.6 |

IDENTIFICATION NUMBER:

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Test #

# ERIE TECHNOLOGICAL PRODUCTS
OF CANADA, LTD.

SHEET # 2 OF 3

NOTES # APPENDIX I

P.O. 17SR70A87549

F.O. 2543101

QTY. 17 pcs.

## QUALITY CONTROL DEP'T. – RECORDED DATA SHEET

FILE NO. ETR 0019

TEST Environmental Evaluation

PART TSK 312-000 (6 stage rectangular mult. module)

SPECIAL DETAILS Re.: Fort Monmouth Specification SCS-495

Start Date 12 Oct./77

Finish Date 19 Oct./77

Tested By D.A. F.T.

Approved By QC Insp ERIE 20

| TEST DATE: | 12 Oct./77 | | | | | 13 Oct./77 | | | | | 13 Oct./77 | 19 Oct./77 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST COND. | HIGH TEMPERATURE PERFORMANCE @ +50°C | | | | | LOW TEMPERATURE PERFORMANCE @ -54°C | | | | | THERMAL SHOCK | HIGH TEMP. STORAGE |
| INPUT VOLT. | 1000Vp/p | 1000Vp/p | 1000Vp/p | 500Vp/p | 1000Vp/p | 1000Vp/p | 1000Vp/p | 1000Vp/p | 500Vp/p | 1000Vp/p | | |
| TEST FREQ. | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | | |
| LOAD CURRENT | < 2 nA | < 2 nA | < 2 nA | < 2 nA | 500 nA | < 2 nA | < 2 nA | < 2 nA | < 2 nA | 500 nA | NON- | NON- |
| PARAMETER | O/P Volt | Rip Volt | Chg Cur | Cap | O/P Volt | O/P Volt | Rip Volt | Chg Cur | Cap | O/P Volt | OPER- | OPER- |
| UNITS | Vdc | Vp/p | µA | pF | Vdc | Vdc | Vp/p | µA | pF | Vdc | ATIONAL | ATIONAL |
| REQUIREMENT | 3241 | 32414 < 3% | 32413 < 300 µA | 32412 < 8 pF | Eff 80% min | 3242 | 32524 < 3% | 32432 < 150 µA | 32422 < 8 pF | Eff 80% min | 32431 | 32432 |
| No. 32 | | | | | 5750 | | | | | 5800 | | |
| 34 | | | | | 5750 | | | | | 5800 | | |
| 35 | | | | | 5750 | | | | | 5800 | | |
| 36 | 5810 | 43 | 340 ✓ | 8.69 ✓ | 5750 | 5830 | 45.6 | 230 ✓ | 8.40 ✓ | 5800 | | |
| 39 | | | | | 5750 | | | | | 5800 | | |
| 41 | | | | | 5750 | | | | | 5800 | | |
| 42 | | | | | 5750 | | | | | 5800 | | |
| 43 | | | | | 5750 | | | | | 5800 | | |
| 44 | | | | | 5750 | | | | | 5800 | | |
| 46 | | | | | 5750 | | | | | 5800 | | |
| 48 | | | | | 5750 | | | | | 5800 | | |
| 49 | 5800 | 24.7 | 320 ✓ | 8.52 ✓ | 5750 | 5820 | 28.7 | 240 ✓ | 7.87 | 5800 | | |
| 51 | | | | | 5750 | | | | | 5800 | | |
| 52 | | | | | 5750 | | | | | 5800 | | |
| 56 | 5800 | 22.1 | 300 ✓ | 7.45 | 5750 | 5830 | 26.0 | 230 ✓ | 7.27 | 5800 | | |
| 57 | | | | | 5750 | | | | | 5800 | | |
| 58 | | | | | 5750 | | | | | 5800 | | |
| | | | | (EFFICIENCY = 95.8) | | | | | (EFFICIENCY = 96.7) | | | |

IDENTIFICATION NUMBER:

NOTE: ONLY THREE MULTIPLIERS WERE CHECKED FOR ALL TEST CONDITIONS AT THE TEMPERATURE EXTREMES.

THERMAL SHOCK: Per MIL. STD. 202, 107D, B-1 25 cycles with each cycle being ½ hr. at each extreme -65°C & +71°C

HIGH TEMP. STORAGE: Mult's subjected to an eight (8) hr. non-operational storage test @ +71°C

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Test #

# ERIE TECHNOLOGICAL PRODUCTS
OF CANADA, LTD.

SHEET # 3 OF 3
NOTES # APPENDIX I
P.O. 17SR70A87549
F.O. 2543101
QTY. 17 pcs.

**QUALITY CONTROL DEP'T. - RECORDED DATA SHEET**
FILE NO. E.T.R. 009

TEST Electrical Evaluation (POST ENVIRONMENTAL)
PART TSK 312-000 (6 stage rectangular mult. module)
SPECIAL DETAILS Re.: Fort Monmouth Specification SCS-495

Start Date 20 OCT. 77
Finish Date 20 OCT. 77
Tested By D.A.
Approved By QC Insp ERIE 20

| TEST DATE | | | | | | |
|---|---|---|---|---|---|---|
| TEST COND. | "A" | "B" | "C" | "D" | "E" | "A - E" |
| INPUT VOLT. | 1000 V pk to pk | 1000 V pk to pk | 1000 V pk to pk | 500 V pk to pk | 1000 V pk to pk | 1000 V pk to pk |
| TEST FREQ. | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz |
| LOAD CURRENT | < 2 nA | < 2 nA | | | 500 nA | to 500 nA |
| PARAMETER | OUTPUT VOLTAGE | RIPPLE VOLTAGE | CHARGE CURRENT | INPUT CAPACITANCE | OUTPUT VOLTAGE | CAL. EFFICIENCY |
| UNITS | Vdc | Vp/p | µA | pF | Vdc | % |
| REQUIREMENT | Para 3.2.1 | Para 3.2.1.4 <3% p/p | Para 3.2.1.3 <150 µA | Para 3.2.1.2 < 8 pF | Para 3.2.1 | Para 3.2.1.1 85% minimum |
| No. 32 | 5860 | 36.4 | 250 ✓ | 7.77 | 5820 | 97.0 |
| 34 | 5870 | 31.2 | 250 ✓ | 7.69 | 5820 | 97.0 |
| 35 | 5860 | 28.6 | 260 ✓ | 7.85 | 5820 | 97.0 |
| 36 | 5850 | 31.2 | 255 ✓ | 7.82 | 5820 | 97.0 |
| 39 | 5820 | 33.8 | 260 ✓ | 7.75 | 5800 | 96.7 |
| 41 | 5820 | 35.1 | 255 ✓ | 7.92 | 5810 | 96.8 |
| 42 | 5860 | 31.2 | 250 ✓ | 7.64 | 5820 | 97.0 |
| 43 | 5880 | 31.2 | 255 ✓ | 8.09 ✓ | 5850 | 97.5 |
| 44 | 5860 | 32.5 | 245 ✓ | 7.66 | 5820 | 97.0 |
| 46 | 5850 | 37.7 | 250 ✓ | 8.00 | 5820 | 97.0 |
| 48 | 5820 | 26.0 | 255 ✓ | 8.04 ✓ | 5810 | 96.8 |
| 49 | 5820 | 29.9 | 255 ✓ | 7.82 | 5800 | 96.7 |
| 51 | 5810 | 35.1 | 255 ✓ | 7.98 | 5800 | 96.7 |
| 52 | 5850 | 32.5 | 250 ✓ | 7.74 | 5810 | 96.8 |
| 56 | 5810 | 32.5 | 255 ✓ | 8.00 | 5800 | 96.7 |
| 57 | 5810 | 30.0 | 260 ✓ | 8.06 ✓ | 5800 | 96.7 |
| 58 | 5840 | 32.5 | 255 ✓ | 7.96 | 5810 | 96.8 |

IDENTIFICATION NUMBER:

NOTE: THE FOLLOWING EIGHT (8) MULTIPLIERS WERE PREVIOUS SHIPPED AS 1ST ENG. SAMPLES-
IDENT No's: 36, 39, 41, 43, 44, 48, 49

NOTE: THE FOLLOWING SIXTEEN (16) MULTIPLIERS WERE SHIPPED AS 2ND ENG. SAMPLES-
IDENT No's: 32, 34, 35, 36*, 39*, 41*, 42, 43*, 44*, 46, 48*, 49*
51, 52*, 56, 58.

Test .

# ERIE TECHNOLOGICAL PRODUCTS
OF CANADA, LTD.

## QUALITY CONTROL DEP'T. – RECORDED DATA SHEET

FILE NO. E.T.R. 0019

SHEET # 1 OF 3
NOTES # APPENDIX II
P.O. 17SR70A87549
F.O. 2543101
QTY. 14pcs.

TEST Electrical Evaluation (PRE ENVIRONMENTAL)
PART TSK 313-000 (6 stage curved multiplier module)
SPECIAL DETAILS Re.: Fort Monmouth Specification SCS-495

Start Date 26 SEPT./77
Finish Date 27 SEPT./77
Tested By D.A.
Approved By (QC Insp ERIE 20)

| | "A" | "B" | "C" | "D" | "E" | "A – E" |
|---|---|---|---|---|---|---|
| TEST DATE | | | | | | |
| TEST COND. | | | | | | |
| INPUT VOLT. | 1000 V pk to pk | 1000 V pk to pk | 1000 V pk to pk | 500 V pk to pk | 1000 V pk to pk | 1000 V pk to pk |
| TEST FREQ. | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz |
| LOAD CURRENT | < 2 nA | < 2 nA | | | 500 nA | to 500 nA |
| PARAMETER | OUTPUT VOLTAGE | RIPPLE VOLTAGE | CHARGE CURRENT | INPUT CAPACITANCE | OUTPUT VOLTAGE | CAL. EFFICIENCY |
| UNITS | Vdc | Vp/p | µA | pF | Vdc | % |
| REQUIREMENT | Para 3.2.1 | Para 3.2.1.4 < 3% p/p | Para 3.2.1.3 < 150 µA | Para 3.2.1.2 < 8 pF | Para 3.2.1 | Para 3.2.1.1 85% minimum |
| No. 5 | 5960 | 18.2 | 290 ✓ | 9.92 ✓ | 5910 | 98.5 |
| 6 | 5950 | 18.2 | 280 ✓ | 9.46 ✓ | 5900 | 98.3 |
| 7 | 5600 | 20.8 | 265 ✓ | 9.36 ✓ | 5550 | 92.5 |
| 8 | 5540 | 52.0 | 250 ✓ | 8.64 ✓ | 5400 | 90.0 |
| 9 | 5900 | 16.9 | 270 ✓ | 9.36 ✓ | 5900 | 98.3 |
| 10 | 5960 | 16.9 | 280 ✓ | 9.67 ✓ | 5910 | 98.5 |
| 11 | 5980 | 15.6 | 280 ✓ | 9.74 ✓ | 5920 | 98.6 |
| 12 | 5920 | 15.6 | 280 ✓ | 9.37 ✓ | 5900 | 98.3 |
| 13 | 5990 | 14.3 | 280 ✓ | 9.08 ✓ | 5920 | 98.6 |
| 14 | 5960 | 18.2 | 275 ✓ | 9.36 ✓ | 5910 | 98.5 |
| * 15 | 4800 | * 260.0 | ~~670~~ | ~~61.63~~ | ~~4790~~ | ~~79.8~~ |
| 16 | 5980 | 16.9 | 265 ✓ | 9.10 ✓ | 5970 | 99.5 |
| * 17 | 5680 | 96.2 | 250 ✓ | 8.66 ✓ | * 5180 | ~~86.3~~ |
| 18 | 5970 | 19.5 | 275 ✓ | 9.28 ✓ | 5910 | 98.5 |

IDENTIFICATION NUMBER:

* NOTE: UNIT NO. 15 REJECTED FOR HIGH RIPPLE VOLTAGE, REMOVED FROM LOT
UNIT NO. 17 REMOVED FROM LOT FOR LOW OUTPUT VOLTAGE @ FULL LOAD.
BALANCE QTY. OF 12 pcs. PROCEED TO ENVIRONMENTAL TESTING.

Test #

# ERIE TECHNOLOGICAL PRODUCTS
OF CANADA, LTD.

## QUALITY CONTROL DEP'T. - RECORDED DATA SHEET

FILE NO. E.T.R.0019

SHEET # 2 OF 3
NOTES # APPENDIX II
P.O. 17SR70A87549
F.O. 2543101
QTY. 12pcs.

TEST Environmental Evaluation
PART TSK 313-000 (6 stage curved multiplier module)
SPECIAL DETAILS Re.: Fort Monmouth Specification SCS-495

Start Date 12 Oct./77
Finish Date 19 Oct./77
Tested By D.A. F.T.
Approved By QC Insp ERIE 20

| TEST DATE | 12 Oct./77 | | | | | 13 Oct./77 | | | | | 13 Oct./77 | 19 Oct./77 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEST COND. | HIGH TEMPERATURE PERFORMANCE @ +50°C | | | | | LOW TEMPERATURE PERFORMANCE @ -54°C | | | | | THERMAL SHOCK | HIGH TEMP. STORAGE |
| INPUT VOLT. | 1000Vp/p | 1000Vp/p | 1000Vp/p | 500Vp/p | 1000Vp/p | 1000Vp/p | 1000Vp/p | 1000Vp/p | 500Vp/p | 1000Vp/p | | |
| TEST FREQ. | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | | |
| LOAD CURRENT | <2 nA | <2 nA | <2 nA | <2 nA | 500 nA | <2 nA | <2 nA | <2 nA | <2 nA | 500 nA | NON- | NON- |
| PARAMETER | O/P Volt | Rip Volt | Chg Cur | Cap | O/P Volt | O/P Volt | Rip Volt | Chg Cur | Cap | O/P Volt | OPER- | OPER- |
| UNITS | Vdc | V p/p | μA | pF | Vdc | Vdc | V p/p | μA | pF | Vdc | ATIONAL | ATIONAL |
| REQUIREMENT | 3241 | 32414 < 3% | 32413 < 300 μA | 32412 < 8 pF | Eff 80% min | 3242 | 32524 < 3% | 32432 < 150 μA | 32422 < 8pF | Eff 80% min | 32431 | 32432 |
| No. 5 | 5870 | 19.5 | 320 ✓ | 9.58 ✓ | 5800 | 5880 | 20.8 | 240 ✓ | 8.77 ✓ | 5850 | | |
| 6 | | | | | 5800 | | | | | 5850 | | |
| 7 | | | | | 5800 | | | | | 5850 | | |
| 8 | | | | | 5800 | | | | | 5850 | | |
| 9 | | | | | 5800 | | | | | 5850 | | |
| 10 | | | | | 5800 | | | | | 5850 | | |
| 11 | 5880 | 15.6 | 380 ✓ | 10.33 ✓ | 5800 | 5900 | 19.5 | 280 ✓ | 5.32 | 5850 | | |
| 12 | | | | | 5800 | | | | | 5850 | | |
| 13 | | | | | 5800 | | | | | 5850 | | |
| 14 | | | | | 5800 | | | | | 5850 | | |
| 16 | | | | | 5800 | | | | | 5850 | | |
| 18 | | | | | 5800 | | | | | 5850 | | |
| | | | (EFFICIENCY = 96.7) | | | | | (EFFICIENCY = 97.5) | | | | |

IDENTIFICATION NUMBER:

THERMAL SHOCK: Per MIL. STD. 202, 107D, B-1 25 cycles with each cycle being ½ hr. at each extreme -65°C & +71°C

HIGH TEMPERATURE STORAGE: Mult's subjected to an eight (8) hr. non-operational storage test @ +71°C

NOTE: ONLY TWO MULTIPLIERS WERE CHECKED FOR ALL TEST CONDITIONS AT THE TEMPERATURE EXTREMES.

Test .

# ERIE TECHNOLOGICAL PRODUCTS
OF CANADA, LTD.

SHEET # 3 OF 3
NOTES # APPENDIX II
P.O. 17SR70A87549
F.O. 2543101
QTY. 12pcs.

## QUALITY CONTROL DEP'T. - RECORDED DATA SHEET
FILE NO. ETR-0019

TEST Electrical Evaluation (POST ENVIRONMENTAL)
PART TSK 313-000 (6 stage curved multiplier module)
SPECIAL DETAILS Re.: Fort Monmouth Specification SCS-495

Start Date 20 Oct./77
Finish Date 20 Oct./77
Tested By D.A.
Approved By QC Insp ERIE 20

| | | | | | | |
|---|---|---|---|---|---|---|
| TEST DATE | | | | | | |
| TEST COND. | "A" | "B" | "C" | "D" | "E" | "A - E" |
| INPUT VOLT. | 1000 V pk to pk | 1000 V pk to pk | 1000 V pk to pk | 500 V pk to pk | 1000 V pk to pk | 1000 V pk to pk |
| TEST FREQ. | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz | 30 KHz |
| LOAD CURRENT | < 2 nA | < 2 nA | | | 500 nA | to 500 nA |
| PARAMETER | OUTPUT VOLTAGE | RIPPLE VOLTAGE | CHARGE CURRENT | INPUT CAPACITANCE | OUTPUT VOLTAGE | CAL. EFFICIENCY |
| UNITS | Vdc | Vp/p | µA | pF | Vdc | % |
| REQUIREMENT | Para 3.2.1 | Para 3.2.1.4 < 3% p/p | Para 3.2.1.3 < 150 µA | Para 3.2.1.2 < 8 pF | Para 3.2.1 | Para 3.2.1.1 85% minimum |
| IDENTIFICATION NUMBER: No. 5 | 5910 | 18.2 | 285 ✓ | 9.84 ✓ | 5900 | 98.3 |
| 6 | 5910 | 16.9 | 275 ✓ | 9.50 ✓ | 5900 | 98.3 |
| 7 | 5920 | 20.8 | 260 ✓ | 9.34 ✓ | 5900 | 98.3 |
| 8 | 5400 | 63.7 | 250 ✓ | 8.54 ✓ | 5390 | 89.8 |
| 9 | 5810 | 14.3 | 260 ✓ | 9.43 ✓ | 5800 | 96.6 |
| 10 | 5910 | 15.6 | 275 ✓ | 9.68 ✓ | 5900 | 98.3 |
| 11 | 5930 | 15.6 | 275 ✓ | 9.75 ✓ | 5900 | 98.3 |
| 12 | 5920 | 14.3 | 275 ✓ | 9.30 ✓ | 5900 | 98.3 |
| 13 | 5920 | 13.0 | 270 ✓ | 9.02 ✓ | 5900 | 98.3 |
| 14 | 5920 | 16.9 | 270 ✓ | 9.38 ✓ | 5900 | 98.3 |
| 16 | 5920 | 14.3 | 255 ✓ | 9.10 ✓ | 5900 | 98.3 |
| 18 | 5920 | 18.2 | 265 ✓ | 9.21 ✓ | 5900 | 98.3 |

NOTE: THE FOLLOWING EIGHT (8) MULTIPLIERS WERE SHIPPED AS 2ND ENG. SAMPLES -
IDENT. NO'S.: 5, 6, 10, 11, 12, 13, 14, 16