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

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

Further steps to improve the performance of the multipliers and optimization of the rectifiers for these devices are discussed.

EIGHTH QUARTERLY PROGRESS REPORT

1 APRIL 1978 TO 30 JUNE 1978

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 eighth quarter of work on the Manufacturing and Technology Program for Miniature High Voltage Multiplier Modules is described in this report.

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

Further steps to improve the performance of the multipliers and optimization of the rectifiers for these devices are discussed.

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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 image intensifier tubes. The full scope and details of the specification are given in Appendix A to the Eighth 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)
vr	-	ripple voltage (V)
V_B	-	breakdown voltage (V)
V_i	-	input voltage (Vp – p)
V_o	-	output voltage (V d.c.)
η	-	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.

In the Sixth and Seventh Quarterly Reports were presented the results of testing of rectangular and curved multipliers to the Second Engineering Sample requirements, steps to improve the frequency performance of the multipliers and optimization of the rectifiers for these devices, as well as results of life testing of multipliers.

2. FABRICATION AND EVALUATION OF MULTIPLIERS

2.1 General

The Program Manager received the authorization to proceed to the Confirmatory Sample Phase on May 11, 1978 in a telephone call from the Administrative Contracting Officer, Capt. R. L'Heureux, U.S. Army ERADCOM.

Approval of the specification SCS-495 "Miniature High Voltage Hybrid Multiplier Modules" updated 20 January, 1978 was also granted then. The updated specification is given in Appendix A.

A formal letter confirming these approvals is expected soon.

2.2 Reliability Testing Of Multipliers

Failure Analysis Reports for the multipliers which were taken off the reliability test were prepared by the High Voltage Products Q.C. and are given in Appendix B. The main conclusion is that the multipliers cannot withstand continuous operation with a 115% over voltage applied without additional encapsulation. Future life testing will be done on multipliers encapsulated in a manner that simulates the application of the devices in practical circuits. To achieve this, the remaining parts were potted with RTV II silicone compound.

Of the parts that failed on life test, four did so within 48 hours from being put on test, or from a drastic change of test conditions. These parts would normally be eliminated from further tests, since there is a 48 hr. burn-in required for all parts at 52°C, with the input voltage of 1,150 Volts peak-to-peak.

Two other failures occurred together and were probably related. Internal arcing at the rectifier-capacitor contacts was found in two cases, which could have been caused by bad assembly or misalignment of the capacitors and rectifier-substrate assemblies. There is also a suspicion of deterioration of the conductive epoxy bonds between the capacitors and rectifiers.

Conductive epoxy is very widely used in electronic assembly with good results. One could imagine, however, the deterioration of the contacts being due to a chemical process of the silver in the paste. This could be improved by changing to a gold based conductive epoxy, which is much more expensive.

Elimination of the conductive epoxy contacts would require a complete re-design of the device.

At this stage it is probably best to proceed with the Confirmatory Sample without any major modifications of the design and the manufacturing process and obtain a better view of the reliability of the parts after completing the life testing of the Confirmatory Sample.

Up to now, the rectifiers were only tested before potting in the substrate. In order to improve the reliability of the multipliers by eliminating a possible cause of failures, we will perform additional electrical testing of the rectifier-substrate assemblies after potting the rectifiers and lapping the substrate assemblies. For this purpose a jig was fabricated, which would allow contacting individual rectifiers sequentially in the substrate assembly, applying first forward, and then reverse voltage to them and testing the forward voltage drop, breakdown voltage, and reverse leakage current.

The rectifier tester itself is available, having been built recently for another project (development of High Voltage Rectifier Banks).

One rectangular multiplier (# 57) from the First Engineering Sample, which survived without failure 2616 hours of reliability testing, as well as 2 multipliers (# 8A - curved, and # 76 rectangular) from the Second Engineering Sample which have previously logged 1272 hours, were put back on test.

Two more multipliers (# 81 and # 82), both rectangular, retained from the submission of April 4, 1978, were put on test, too. The latter multipliers were made using HSC 2 rectifier.

All the multipliers for this test were potted in RTV II silicone compound to eliminate external corona effects.

The test conditions were the same as previously and conform to the SCS-495 specification:

Temperature	+50°C
Input Voltage	1150V
Load Current	500 nA

Within 48 hours from the start of the test, unit # 81 exhibited a failure of one stage, with the output voltage reduced to 4.3 kV, and was removed from the test.

The remaining 4 units logged 1632 additional hours by the end of June without new failures: one part (# 57) logged 4248 hrs., 2 parts (# 76 and 8A) logged 2904 hrs., and one (# 82) logged 1632 hrs.

2.3 Multiplier Design

Problems were reported previously with the holes in the glass-epoxy substrates being too shallow for the 3-junction, and occasionally even for the 2-junction rectifiers. When the upper nailheads were not covered with the potting epoxy, the leads would break off at lapping.

To alleviate this, we tightened up the tolerances on the TSK 312-104 and TSK 313-104 drawings of, respectively, the rectangular and curved substrate plates. The thickness of both substrates was changed from .062" ± .008" to .070" ± .003". This yields the holes depth of .062" ± .005", rather than the previous .052", + .010", - .013". It is still possible to use standard 1/16" thick laminate sheets to fabricate the substrate, but they have to be selected closer to its upper thickness tolerance limit.

The drawings TSK 312-104 Rev. A and TSK 313-104 Rev. A are on Fig. 1 and 2, respectively.

With the deeper holes, we should be able to use 3-junction devices HSC-3 rather than the 2-junction version, HXC-2. The maximum length between the nail-heads is .058" for the HSC-3 devices, and .047" for HXC-2.

To reduce the rectifiers' length we redesigned the leads, changing the thickness of the nailhead from a maximum of .013" to .0085". An evaluation lot of 10,000 rectifier leads (HVR04M-13) has been ordered for delivery by August 15, 1978.

There are two main advantages in reverting to the 3-junction device.

1. The junction capacitance is by a quarter to a third lower. We were not able to meet the updated SCS-495 specification with rectifiers having the capacitance above 0.6 pF at 100 V and 1 MHz, but we were successful with rectifiers with capacitances averaging 0.22 pF and the highest value in the sample lot below 0.30 pF. To achieve this low capacitance, the rectifier junction area must be etched down considerably, with excessive mechanical breakage and poor repetibility. The situation will be much easier with 3-junction devices.

2. The operating voltage per junction is decreased from 500 V to 330 V, which improves the reliability of the devices.

We are adding to the specification of the rectifier RD0058 the maximum capacitance of 0.35 pF at 100 V and 1 MHz, and the maximum reverse recovery time of 250 ns measured in the Tektronix S circuit with both the forward and reverse currents of 2 mA.

The acceptance testing limits of the rectifiers shall include;

1.	Forward voltage drop @ i_F = 10 mA	Min. 2.5 V Max. 4.5 V
2.	Peak Inverse Voltage @ i_R = 1 μA max.,	Min. 3000 V
3.	Reverse Current @ V_R = 1 kV	Max. 10 nA
4.	Capacitance @ V_R = 100 V, f = 1 MHz	Max. .35 pF
5.	Reverse Recovery Time, Tektronix S Circuit $i_F = i_R = 2$ mA	Max. 250 ns

All testing to be done at 25°C ± 5°C ; during the PIV test the devices are to be immersed in fluorinert FC-43, fluorochemical liquid of 3M Co., St. Paul, Minn. The reverse current test must be done with the devices shielded from light to eliminate photoelectric current effects. The outline of the device is given on Fig. 1 in the Fourth Quarterly Report.

The cure of epoxy used for potting the rectifiers in the substrates is done at 200°C. It would be advantageous to do the cure at a higher temperature, but carbonization of the laminated substrate binding resin prevents us from doing so. We will evaluate polyimide for the fabrication of substrates.

The properties of G-10 glass epoxy boards (from the Modern Plastics Encyclopedia, Vol. 46, No. 10A, 1969, pp 400 - 401) and SP-1 polyimide manufactured by DuPont (manufacturers data sheet) are compared below;

	G-10	SP-1	Unit
Tensile strength	35 - 40	12.5	1000 psi
Max. operating temperature	140	260	deg. C
Dielectric strength	500	560	V/mil
Dielectric constant	5.2	3.62	-----
Dissipation factor	.025	.002	-----

Under every important respect polyimide is superior. Unfortunately it is much more expensive and difficult to come by. We have located 2 suppliers. Atlantic Laminates, Franklin, N.H., can deliver it in the form of .070" glass-cloth laminate with a minimum order of $2,000. DuPont can supply polyimide rods from which substrates can be machined. This is a little more costly in production, than use of sheets of exactly the thickness needed, but the minimum order was \$160. We have placed an order with DuPont for a sample polyimide rod ($1\frac{1}{2}$" dia. and $9\frac{1}{2}$" long).

A jig to hold the substrates during the potting operation is being designed. Up to now the parts were held in a clip. This works reasonably well when the quantities are small, but the rubber holding the substrates had to be replaced often, because it would stick to the substrates if epoxy over-flowed.

3. CONCLUSIONS

Based on the results of Second Engineering Samples testing, and of the analysis of reliability testing, it is recommended to proceed with the Confirmatory Sample without any major modifications of the design and the manufacturing process.

Some minor changes, all of which should improve the reliability of the multiplier should be considered.

4. PROGRAM FOR NEXT QUARTER

4.1 Manufacture the confirmatory sample lot.

5. PUBLICATIONS AND REPORTS

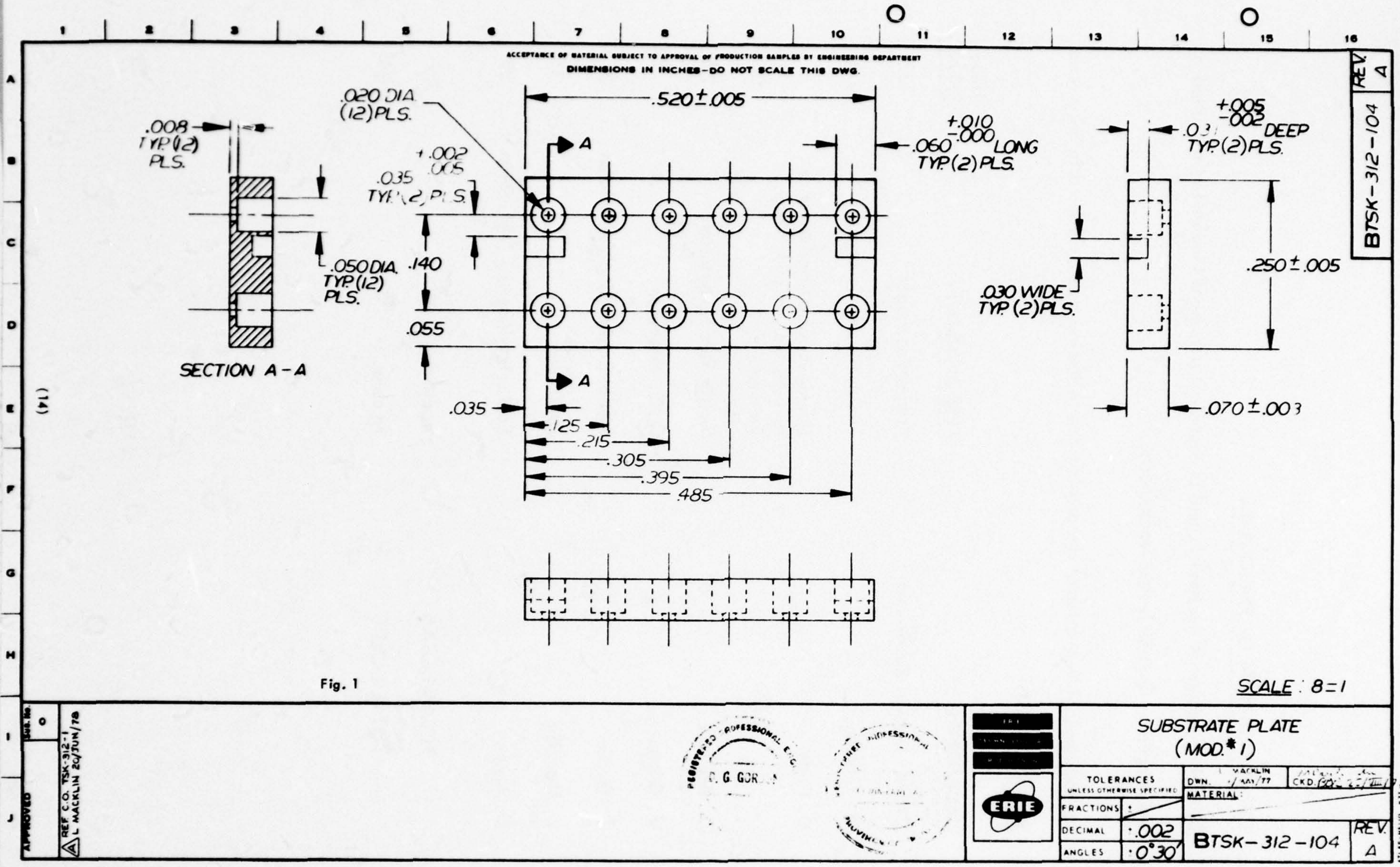
No reports or publications were made on the work associated with this program during the current quarter.

6. IDENTIFICATION OF PERSONNEL

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

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

INDIVIDUAL	RESPONSIBILITY	HRS. SPENT
Dr. M. Korwin-Pawlowski	Program Manager	127
G. Gordon	Senior Electronic Engineer	6
D. Platt	Manager, Quality Assurance and Control, High Voltage Products	16
D. Archard	Senior Test Technician	78
V. Glenn	Q.C. Inspector	6
C. Grills	Senior Engineering Technician	31
L. Macklin	Draftsman	15
D. Regan	Senior Engineering Technician	50
TOTAL HOURS -	in quarter	329
TOTAL HOURS -	to date	4039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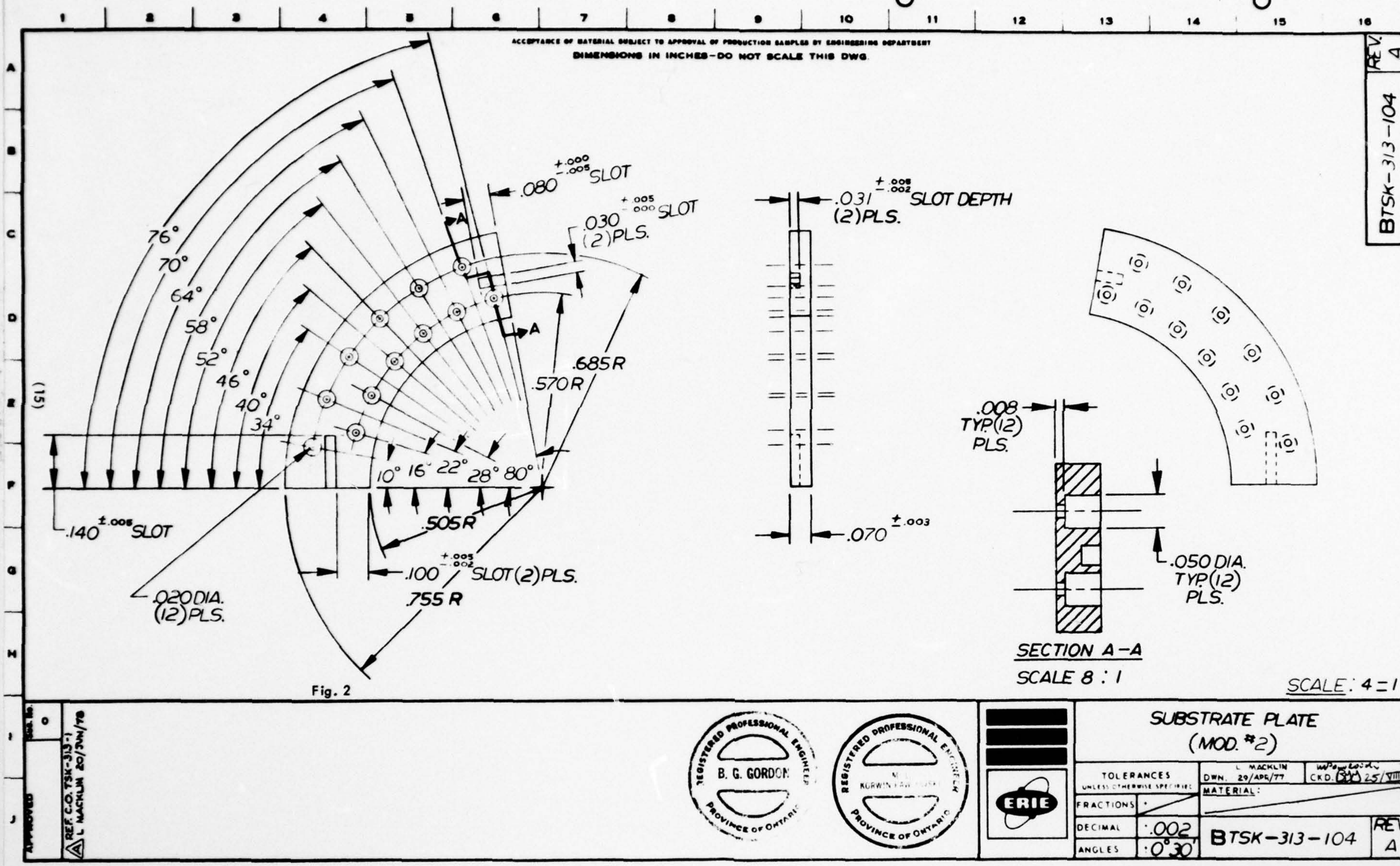
DIMENSIONS IN INCHES—DO NOT SCALE THIS DWG.
.008 TYP.(12) PLS.
.020 DIA (12)PLS.
.520 ± .005
+.002 -.005 .035 TYP.(2) PLS.
.050 DIA. TYP.(12) PLS.
.140
.055
SECTION A-A
A
.060 +.010 -.000 LONG TYP.(2)PLS.
.031 +.005 -.002 DEEP TYP.(2)PLS.
.030 WIDE TYP.(2)PLS.
.250 ± .005
.070 ± .003
.035
.125
.215
.305
.395
.485
SCALE : 8=1
SUBSTRATE PLATE (MOD.# 1)
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ±
DECIMAL ± .002
ANGLES ± 0°30'
DWN. L. MACKLIN
CKD.
MATERIAL:
BTSK-312-104
REV. A
ERIE
REF C.O. TSK-312-1 L. MACKLIN 20/JUN/78
APPROVED
Fig. 1



ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES—DO NOT SCALE THIS DWG.
76°
70°
64°
58°
52°
46°
40°
34°
10°
16°
22°
28°
80°
.080 +.000 -.005 SLOT
.030 +.005 -.000 SLOT (2)PLS.
.685 R
.570 R
.505 R
.755 R
.140 ±.005 SLOT
.100 +.005 -.002 SLOT (2)PLS.
.020 DIA. (12)PLS.
A
A
.031 +.008 -.002 SLOT DEPTH (2)PLS.
.070 ±.003
.008 TYP.(12) PLS.
.050 DIA. TYP.(12) PLS.
SECTION A–A
SCALE 8 : 1
SCALE: 4 = 1
BTSK-313-104
REV. A
SUBSTRATE PLATE (MOD. #2)
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS
DECIMAL .002
ANGLES 0°30'
DWN. L. MACKLIN 29/APR/77
CKD. 25/VIII/77
MATERIAL:
REV. A
B. G. GORDON
REGISTERED PROFESSIONAL ENGINEER PROVINCE OF ONTARIO
ERIE
A REF. C.O. TSK-313-1 L MACKLIN 20/JUN/78
APPROVED

Fig. 2

APPENDIX A

UPDATED SPECIFICATION FOR

MINIATURE HIGH VOLTAGE HYBRID MULTIPLIER MODULES

20 January 1978

MINIATURE HIGH VOLTAGE HYBRID MULTIPLIER MODULES

1. SCOPE

1.1 This specification covers the requirements for miniature high voltage hybrid multiplier modules for use in low cost power supplies for image intensifier tubes.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Military

MIL - P - 11268	Parts, Maintenance, and Processing used in Electronic Equipment

STANDARDS

Military

MIL - STD - 105	Sampling Procedures and Tables for Inspection by Attributes
MIL - STD - 109	Quality Assurance Terms and Definitions
MIL - STD - 129	Marking for Shipment and Storage
MIL - STD - 130	Identification Marking of U.S. Military Property
MIL - STD - 202	Test Methods for Electronic and Electrical Component Parts
MIL - STD - 454	Standard General Requirements for Electronic Equipment
MIL - STD - 456	Electronic Parts, Date and Source Coding for
MIL - STD - 781	Reliability Test Exponential Distributions

3. REQUIREMENTS

3.1 Item Definition. The miniature high voltage hybrid multiplier module, hereafter called the multiplier, shall be a solid state electronic device to convert a sinusoidal (AC) input voltage to a high DC output voltage. The multiplier shall consist of a "6" stage diode capacitor array connected in parallel in accordance with Figure 1.

3.1.1 The major components of the multiplier are the diodes and capacitor array.

3.2 Characteristics.

3.2.1 Room Temperature Performance. The multiplier shall meet the following requirements at room temperature when operated from a 1000 volt peak to peak 35 kHz sine wave input.

3.2.1.1 Multiplier Efficiency. The multiplier efficiency (6.3) shall be a minimum of 94% with no load (less than 2 nanoamps). With full load (500 nanoamps) the efficiency shall not change by more than 2% from its no-load value.

3.2.1.2 Input Capacitance. The input capacitance shall be less than eight (8) picofarads at 1000 volts peak to peak. (See 4.5.3.2)

3.2.1.3 Charging Current. The multiplier peak charging current at no load shall be less than two hundred fifty (250) microamps. (See 4.5.3.3).

3.2.1.4 Ripple Voltage. The multiplier ripple voltage shall be less than 1% peak to peak at no load. (See 4.5.3.4)

3.2.2 Physical Characteristics. The physical characteristics of the multiplier shall be as specified herein.

3.2.2.1 Resistance To Soldering Heat. The multiplier shall suffer no mechanical or electrical damage after its leads have been immersed in a solder bath at 450°F for at least 3 seconds. (See 4.5.6)

3.2.2.2 Solderability. Each multiplier lead shall be at least 95% covered with a solder coating when immersed in a solder bath, and any pinholes shall be concentrated in one area and do not exceed 5% of the total soldered area. (See 4.5.9)

3.2.2.3 Terminal Strength. Each multiplier lead shall be capable of withstanding a $\frac{1}{4}$ pound pull for a minimum of 5 seconds, with no rupturing of the lead or other damage to the lead or multiplier.

3.2.2.4 Dimensions. Dimensions shall be as specified in Figure 3 and 4. (See 4.5.2)

3.2.2.5 Weight. The weight of each multiplier shall not exceed 5 grams. (See 4.5.2)

3.2.3 Reliability (Mean Time To Failure). The multiplier shall have a specified mean time to failure of 25,000 hrs. There shall be no evidence of physical damage and the multiplier shall meet the following requirements:

a.) Multiplier efficiency shall be as specified in 3.2.1.1.

b.) Charging current shall be as specified in 3.2.1.3. (See 4.5.17)

3.2.4 Environmental Conditions.

3.2.4.1 High Temperature Performance. The multiplier shall meet the following requirements at high temperature plus 52° C when operated from a 1000 volt peak to peak 35 kHz sine wave input. (See 4.5.5)

3.2.4.1.1 Multiplier Efficiency. The multiplier efficiency shall not change more than plus or minus 2% from its room temperature efficiency. (See 4.5.5.1)

3.2.4.1.2 Input Capacitance. The input capacitance shall be less than eight (8) picofarads at 1000 volts peak to peak. (See 4.5.5.2)

3.2.4.1.3 Charging Current. The multiplier peak charging current at no load shall be less than 300 microamps. (See 4.5.5.3)

3.2.4.2 Low Temperature Performance. The multiplier shall meet the following requirements at minus 54°C when operated from a 1000 volt peak to peak 35 kHz sine wave input. (See 4.5.4)

3.2.4.2.1 Multiplier Efficiency. The multiplier efficiency shall not change more than plus or minus 2% from its room temperature efficiency. (See 4.5.4.1)

3.2.4.2.2 Input Capacitance. The input capacitance shall be less than eight (8) picofarads at 1000 volts peak to peak. (See 4.5.4.2)

3.2.4.2.3 Charging Current. The multiplier charging current at no load shall be less than 250 microamps.

3.2.4.3 Environmental Stress Conditions.

3.2.4.3.1 Thermal Shock. The multiplier shall show no evidence of mechanical or electrical damage when subjected to thermal shock. (See 4.5.13)

3.2.4.3.2 High Temperature Storage. There shall be no evidence of mechanical or electrical damage after the multiplier has been subjected to a minimum of 8 hours storage at plus 71°C. The multiplier shall be capable of meeting the requirements of 3.2.4.1.1 and 3.2.4.1.3 after it has been subjected to high temperature storage. (See 4.5.14)

3.2.4.3.3 Low Temperature Storage. There shall be no evidence of mechanical or electrical damage after the multiplier has been subjected to a minimum of two (2) hours storage at minus 65°C. The multiplier shall be capable of meeting the requirements of 3.2.4.2.1 and 3.2.4.2.3 after it has been subjected to low temperature storage. (See 4.5.15)

3.2.4.3.4 Humidity Sealing. There shall be no evidence of mechanical or electrical damage after the multiplier has been exposed to a relative humidity of not less than 95% at a temperature of not less than plus 23°C for a period of not less than six (6) hours. (See 4.5.16)

3.2.4.3.5 Mechanical Shock. With the operating potential applied to the multiplier, there shall be no evidence of arcing or breakdown after the multiplier has been subjected to the following mechanical shock. There shall be no evidence of mechanical damage. (See 4.5.12)

3.2.4.3.5.1 Mechanical Shock I. The multiplier shall not be damaged when subjected to 6 shock impacts applied parallel to the radial axis and 6 shock impacts applied perpendicular to the radial axis of the assembly. The shock impacts shall be nominal half sine-wave pulse having a minimum of 500 g's peak value and a duration of 0.3, ±0.05 milliseconds measured between the 10 per cent values of the peak amplitude.

3.2.4.3.5.2 Mechancial Shock II. The multiplier shall not be damaged when subjected to 6 mechancial shock pulses along the perpendicular axis and 6 mechanical shock pulses along the parallel axis at an amplitude of 140 g's half sine-wave peak for 9 milliseconds, ±10 per cent duration.

3.2.4.3.6 Vibration. The multiplier shall not be damaged after being rigidly mounted, and subjected to a 2.5 g's peak sine wave vibration over a frequency range of 10 Hz through 3500 Hz along the longitudinal and transverse axes of the multiplier. (See 4.5.11)

3.2.4.3.7 Reduced Barometric Pressure. The multiplier shall show no evidence of arcing or breakdown after subjection to a barometric pressure of 3.44 inch for one hour. The multiplier shall show no evidence of mechanical damage after subjection to a barometric pressure of 3.44 inch for one hour, (See 4.5.10).

3.3 Design And Construction.

3.3.1 Materials, Components, Design And Construction. Compatible materials, processes and techniques will be utilized for fabricating conductive and dielectric films in predetermined patterns and sequences to provide for the interconnection of diode pellets and capacitors to form a parallel array of cascaded doubler stages. There shall be no adverse physical interaction between thick film components substrate, dielectric or attached active devices. Thick film elements will be considered as compatible only if they have been developed to the point of having all conductive dielectric insulating and passivating films constitute a system wherein no deleterious metallurgical reactions between any one of the system components occurs as a result of any processing or operating sequence. The contractor is not limited in his choice of processes other than that each process used to fabricate the multiplier shall be mutually compatible with each other. The techniques utilized shall have been optimized and capable of being controlled so that the multiplier can be reproducibility and repetitively fabricated with operational, environmental and reliability characteristics equivalent to those requirements specified herein. (See 4.5.12.1)

3.3.1.1 Materials and Components. Materials shall be as specified herein. Materials not specified shall be selected by the contractor and shall be subjected to all provisions of this specification with conformance to MIL - P - 11268.

3.3.1.2 Terminals. (See 4.5.2.1)

3.3.1.2.1 *Terminal Type.* *Terminal* type shall be as shown in Figure 3, and Figure 4.

3.3.1.2.2 Terminal Location And Length. Location and length shall be as specified in Figure 3, and Figure 4.

3.3.2 Identification And Marking. Identification shall be in accordance with Figure 3, and Figure 4. (See 4.5.2.1)

3.3.3 Workmanship. Workmanship shall be in accordance with MIL - STD - 454, requirement 9. The multiplier shall be free from burrs, sharp edges, potting voids, defects and scratches which may affect performance. It shall also be free from grease, oil, dust, solder flux or any other conductive film. The process of fabrication and non-destructive testing shall not deteriorate the characteristics of multiplier performance, material or appearance. (See 4.5.2)

3.3.4 Over Voltage. There shall be no evidence of arcing, or breakdown when the multiplier is subjected for 5 seconds to a voltage of 1300 volts peak to peak 35Hz sine wave. (See 4.5.8)

3.3.5 Burn-In. All multipliers shall be burned in at no load for 48 hours at plus 52°C with the input voltage of 1150 Volts peak to peak. (See 4.3.1 and 4.4.1)

4. QUALITY ASSURANCE PROVISION.

4.1 Responsibility For Inspection. Unless otherwise specified in the contract or purchase order the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may utilize his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the purchase description where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification Of Inspection. The examination and testing of multipliers shall be classified as follows: (a) confirmatory sample inspection (b) quality conformance inspection (does not include preparation for delivery)

4.3 Confirmatory Sample Inspection.

4.3.1 Confirmatory Samples. When specified in the contract or purchase order the contractor shall furnish fifty (50) confirmatory samples of each multiplier.

4.3.2 Confirmatory Sample Inspection. All multipliers shall be burned in in accordance with 3.3.5 prior to initiating the following inspections. Fifty units of each type shall be subjected to the inspections specified in Table I in the order shown. All sample units shall be subjected to the inspection of Group I. Ten sample units shall be subjected to the inspection of Group II. Thirty-five (35) sample units shall be subjected to the inspections of Group III. The remaining five (5) sample units shall be subjected to the inspections of Group IV. No failures shall be permitted.

4.4 Quality Conformance Inspection.

4.4.1 Burn-In. All multipliers shall be burned in in accordance with 3.3.5.

4.4.2 Group A Inspection. Group A inspection shall consist of the examination and tests specified in Table II, in the order shown.

4.4.2.1 Sampling Plan. Statistical sampling and inspection shall be in accordance with MIL - STD - 105 for general inspection level II. The acceptable quality levels (AQL) shall be as specified in Table II. Major and minor defects shall be as defined in MIL - STD - 105.

4.4.2.2 Rejected Lots. If an inspection lot is rejected, the supplier may rework it to correct the defects, or screen out the defective units and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.4.3 Group B Inspection. Group B inspection shall consist of the tests specified in Table III in the order shown. They shall be performed on sample units that have been subjected to and have passed the group A tests unless it is more practical to select a separate sample from the lot for Group B inspection.

4.4.3.1 Sampling Plan. The sampling plan shall be in accordance with MIL - STD - 105 for general inspection level II. The AQL shall be 1.0 percent defective.

4.4.3.2 Rejected Lots. If an inspection lot is rejected, the supplier may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.4.4 Group C Inspection. Group C inspection shall consist of examination and tests specified in Table IV, in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed the Groups A and B inspections. Five (5) sample units shall be selected for Subgroup 1. Five (5) sample units shall be selected and subjected to the inspections of Subgroup II. Thirty five (35) sample units shall be selected for Subgroup III. Three (3) sample units shall be selected and subjected to the inspections of Subgroup IV.

4.4.4.1 Disposition Of Sample Units. Sample units which have been subjected to Group C inspection shall be delivered on the contract or purchase order, if the lot is accepted and the sample units are still within specified electrical tolerance.

4.4.4.2 Noncompliance. If a sample fails to pass Group C inspection, the supplier shall take corrective action on the materials or processes, both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, Group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the Government). Groups A and B inspections may be reinstituted; however, final acceptance shall be withheld until the Group C reinspection has shown that the corrective action was successful. In the event of failure after reinspection information concerning the failure and the corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

4.5 Methods Of Examination And Test.

TABLE I

CONFIRMATORY SAMPLE INSPECTION FOR ELECTRICAL AND ENVIRONMENTAL CHARACTERISTICS AND MECHANICAL DESIGN AND CONSTRUCTION

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Group I		
Visual and mechanical examination (external)	3.3.1.2 3.2.2.4, 3.2.2.5 3.3.2,3.3.3	4.5.2.1
Multiplier Efficiency	3.2.1.1, 3.2.4.1.1 3.2.4.2.1	4.5.3.1, 4.5.5.1 4.5.4.1
Charging Current	3.2.1.3, 3.2.4.1.3 3.2.4.2.3	4.5.3.3, 4.5.5.3 4.5.4.3
Input Capacitance	3.2.1.2, 3.2.4.1.2 3.2.4.2.2	4.5.3.2, 4.5.5.2 4.5.4.2
Group II		
Resistance to Soldering heat	3.2.2.1	4.5.6
Terminal Strength	3.2.2.3	4.5.7
Over Voltage	3.3.4	4.5.8
Solderability	3.2.2.2	4.5.9
Dielectric withstanding Voltage at Barometric Pressure	3.2.4.3.7	4.5.10
Thermal Shock	3.2.4.3.1	4.5.13
High Temperature Storage	3.2.4.3.2	4.5.14
Low Temperature Storage	3.2.4.3.3	4.5.15
Humidity Sealing	3.2.4.3.4	4.5.16
Over Voltage	3.3.4	4.5.8
Multiplier Efficiency	3.2.1.1	4.5.3.1

CONFIRMATORY SAMPLE INSPECTION CONTINUED

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Charging Current	3.2.1.3	4.5.3.3
Input Capacitance	3.2.1.2	4.5.3.2
Visual & Mechanical Examination (external)	3.3.2 3.3.3	4.5.2.1
Visual & Mechanical Examination (internal) (one sample unit)	3.3.1, 3.3.1.1 3.3.3	4.5.2.2
GROUP III		
Reliability	3.2.3	4.5.17
Over Voltage	3.3.4	4.5.8
Visual & Mechanical	3.3.2 3.3.3	4.5.2.1
Multiplier Efficiency	3.2.1.1	4.5.3.1
Charging Current	3.2.1.3	4.5.3.3
Input Capacitance	3.2.1.2	4.5.3.2
GROUP IV		
Mechanical Vibration	3.2.4.3.6	4.5.11
Mechanical Shock	3.2.4.3.5	4.5.12
Over Voltage	3.3.4	4.5.8
Ripple Voltage	3.2.1.4	4.5.3.4

TABLE II

GROUP A INSPECTION

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH	AQL (PERCENT DEFECTIVE) MAJOR	MINOR
Visual and Mechanical Examination (external)	3.3.1.2, 3.2.2.4 3.2.2.5, 3.3.2 3.3.3	4.5.2.1	0.65	4.0
Over Voltage	3.3.4	4.5.8	0.65	--
Multiplier Efficiency	3.2.1.1	4.5.3.1	0.65	--
Charging Current	3.2.1.3	4.5.3.3	0.65	--
Input Capacitance	3.2.1.2	4.5.3.2	0.65	--

TABLE III

GROUP B INSPECTION

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
Multiplier Efficiency	3.2.4.1.1, 3.2.4.2.1	4.5.5.1, 4.5.4.1
Charging Current	3.2.4.1.3, 3.2.4.2.3	4.5.5.3, 4.5.4.3
Input Capacitance	3.2.4.1.2, 3.2.4.2.2	4.5.5.2, 4.5.4.2

TABLE IV

GROUP C INSPECTION

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
GROUP I		
Thermal Shock	3.2.4.3.1	4.5.13
Over Voltage	3.3.4	4.5.8
High Temperature Storage	3.2.4.3.2	4.5.14
Low Temperature Storage	3.2.4.3.3	4.5.15
GROUP 2		
Resistance to Soldering heat	3.2.2.1	4.5.6
Terminal Strength	3.2.2.3	4.5.7
Humidity Sealing	3.2.4.3.4	4.5.16
Over Voltage	3.3.4	4.5.8
Reduced Barometric Pressure	3.2.4.3.7	4.5.10
Mechanical Vibration	3.2.4.3.6	4.5.11
Mechanical Shock	3.2.4.3.5	4.5.12
Over Voltage	3.3.4	4.5.8.7
Multiplier Efficiency	3.2.1.1	4.5.3.1
Charging Current	3.2.1.3	4.5.3.3
Input Capacitance	3.2.1.2	4.5.3.2
Visual & Mechanical Exam. (external)	3.3.2 3.3.3	4.5.2.1
Visual & Mechanical Exam. (Internal, one sample)	3.3.1, 3.3.1.1 3.3.3	4.5.2.2

GROUP C INSPECTION CONTINUED

EXAMINATION OR TEST	REQUIREMENT PARAGRAPH	METHOD PARAGRAPH
SUBGROUP 3		
Reliability	3.2.3	4.5.17
Over Voltage	3.3.4	4.5.8
Visual & Mechanical Examination (external)	3.3.2, 3.3.3	4.5.2.1
Multiplier Efficiency	3.2.1.1	4.5.3.1.1
Charging Current	3.2.1.3	4.5.3.3
Input Capacitance	3.2.1.2	4.5.3.2
SUBGROUP 4		
Solderability	3.2.2.2	4.5.9
Ripple Voltage	3.2.1.4	4.5.3.4

4.5.1 Inspection Conditions. Test will be conducted in accordance with the test procedures specified herein. Unless otherwise specified, the following conditions shall apply.

a) Inspections and test shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL - STD - 202.

b) 'Rated input voltage' shall be 1000 volts ± 1% peak to peak sine wave input.

c) 'Nominal test frequency' shall be 35 ± 2% kHz

d) 'No-load' shall be less than 2 nanoamp.

e) 'Full load' shall be 500 ± 50 nanoamps.

4.5.2 Visual and Mechanical Examination.

4.5.2.1 External. Multipliers shall be examined to verify that the materials, external design and construction, physical dimensions, weight, marking and workmanship are in accordance with the applicable requirements. (See 3.3.1.2, 3.2.2.4, 3.2.2.5, 3.3.2, 3.3.3)

4.5.2.2 Internal. Multipliers shall be disassembled or sectioned and examined to verify that the materials, internal connections, lead wires, diodes capacitors, internal mounting, potting and workmanship are in accordance with the applicable requirements. (See 3.3.1, 3.3.1.1, 3.3.3)

4.5.3 Room Temperature Electrical Performance.

4.5.3.1 Multiplier Efficiency. With rated voltage applied, the multiplier output voltage shall be measured while the supply frequency is 35 kHz. Measurements shall be performed at no load and full load. (See 3.2.1.1)

4.5.3.2 Input Capacitance. The input capacitance for the multiplier shall be determined by a capacitance bridge or other suitable means at 1000 volt peak to peak at 35 kHz at no load using the circuit of Figure 2. (See 3.2.1.2)

4.5.3.3 Charging Current. The multiplier charging current shall be measured using the circuit of Figure 2. Measurements shall be made at no load at 35 kHz at rated input voltage. (See 3.2.1.3)

4.5.3.4 Ripple Voltage. The multiplier ripple voltage shall be measured using a Jennings Probe or other suitable device. Measurements shall be made with rated voltage applied at 35 kHz at full load of 500 nanoamps. (See 3.2.1.4)

4.5.4 Low Temperature Performance. The multiplier shall be maintained for a minimum of one hour at a temperature of minus 54°C prior to performance of the following tests. (See 3.2.4.2)

4.5.4.1 Multiplier Efficiency. With rated voltage applied the multiplier output voltage shall be measured at 35 kHz. Measurements shall be performed at no load and full load. (See 3.2.4.2.1)

4.5.4.2 Input Capacitance. The input capacitance for the multiplier shall be determined by a capacitance bridge or other suitable means at 1000 volt peak to peak at 35 kHz at no load using the circuit of Figure 2. (See 3.2.4.2.2)

4.5.4.3 Charging Current. The multiplier charging current shall be measured using the circuit of Figure 2. Measurements shall be made at no load at 35 kHz at rated input voltage. (See 3.2.4.2.3)

4.5.5 High Temperature Performance. The multiplier shall be maintained for a minimum of one hour at a temperature of plus 52°C prior to performance of the following tests. (See 3.2.4.1)

4.5.5.1 Multiplier Efficiency. With rated voltage applied the multiplier output voltage shall be measured at 35 kHz. Measurements shall be performed at no load and full load. (See 3.2.4.1)

4.5.5.2 Input Capacitance. The input capacitance for the multiplier shall be determined by a capacitan .e bridge on other suitable means at 1000 volt peak to peak at 35 kHz at no load using the circuit of Figure 2. (See 3.2.4.1.2)

4.5.5.3 Charging Current. The multiplier charging current shall be measured using the circuit of Figure 2. Measurements shall be made at no load at 35 kHz at rated input voltage. (See 3.2.4.1.3)

4.5.6 Resistance to Soldering Heat. Multipliers shall be tested in accordance with method 210 of MIL - STD - 202. The following details shall apply:

a) Special preparation of specimen - Sample units shall not have been soldered during any of the previous tests.

b) Depth of immersion in the molten solder - To a point 1/16 inch from the nearest insulating material.

c) Test-condition 450 F $\pm$ 10 F; immersion 3 seconds (See 3.2.2.1).

4.5.7 Terminal Strength. Multipliers shall be tested for terminal secureness in accordance with method 211 of MIL - STD - 202. The following details and exceptions shall apply:

a) Test - condition letter - A.

b) Applied force - Terminal secureness shall be tested by gradually applying a force of $\frac{1}{4}$ pound to each pin terminal in the direction of the axis of the terminal. (See 3.2.2.3)

4.5.8 Over Voltage. A test voltage sufficient to achieve the required over voltage as specified in 3.3.4 shall be applied. The test potential shall be applied for $5 \pm \frac{1}{2}$ second. There shall be no load. During the test, multipliers shall be examined for evidence of arcing, breakdown of insulations. (See 3.3.4)

4.5.9 Solderability. Multipliers shall be tested in accordance with method 208 of MIL - STD - 202. Each of the terminals is to be tested. (See 3.2.2.2)

4.5.10 Barometric Pressure. Multipliers shall be tested as specified in 3.2.4.3.7 and in accordance with method 105 of MIL - STD - 202. The following details and exception shall apply:

a) Input voltage shall be 1150 V peak to peak.

b) Test - condition letter - A. (See 3.2.4.3.7)

4.5.11 Vibration. The input voltage shall not be applied during vibration. Tolerances on specified frequencies shall be + 1 percent. Mount the multipliers rigidly. Subject the multiplier to simple harmonic motion applied in planes parallel and perpendicular to the radial axis. In 30 minutes vary the frequency from 10 Hz to 3500 Hz and return to 10 Hz in a logarithmic sweep. Perform the frequency sweep twice in each plane. Failure to meet requirements of paragraph 3.2.4.3.6 shall constitute failure of this test.

4.5.12 Mechanical Shock.

4.5.12.1 Mechanical Shock I. The input voltage shall not be applied during the shock. The multiplier shall be rigidly mounted in approved test fixture. Subject the multiplier to the shock impulse specified in 3.2.4.3.5.1. Test shall be monitored with an accelerometer mounted on the test fixture near the multiplier. Pulse shape and amplitudes shall be monitored. Failure to meet the requirements of 3.2.4.3.5.1 shall constitute failure of this test.

4.5.12.2 Mechanical Shock II. This test is to be conducted in the same manner as described in 4.5.12.1. Subject the multiplier to the shock impulse specified in 3.2.4.3.5.2. Failure to meet requirements of 3.2.4.3.5.2 shall constitute failure of this test.

4.5.13 Thermal Shock. Multipliers shall be tested in accordance with method 107D, of MIL - STD - 202. Test condition B-1 shall apply, except that the range shall be from -65 to + 71°C. (See 3.2.4.3.1)

4.5.14 High Temperature Storage. Multipliers shall be subjected to a minimum storage period of 8 hours at plus 71° C. The ambient temperature shall then be gradually lowered to plus 52°C. Measurements shall be made of the multiplier efficiency and charging current in accordance with 4.5.5.1, and 4.5.5.3. (See 3.2.4.3.2)

4.5.15 Low Temperature Storage. Multipliers shall be subjected to a minimum storage period of 2 hours at minus 65°C. The ambient temperature shall then be gradually raised to minus 54°C. Measurements shall be made of the multiplier efficiency and charging current in accordance with 4.5.4.1 and 4.5.4.3. (See 3.2.4.3.3)

4.5.16 Humidity Sealing. Multipliers shall be exposed to a relative humidity of not less than 95% at a temperature of plus 23°C for 6 hours. The multiplier shall be tested with an input voltage of 1150 V p-p within 6 hours after removal from the humidity chamber, for a period of 48 hours. (See 3.2.4.3.4)

4.5.17 Reliability. Multipliers shall be life tested at 52 ± 5°C. Operation shall be continuous at full load of 500 nanoamps. Applied input voltage shall be 1150 V p-p. The electrical test circuit shall be monitored over each day so that an open circuit or short circuit during full load operation can be detected and the time of failure recorded. Measurements shall be made of the multiplier efficiency after 200 hours of operating time and after completing the test. Testing shall be in accordance with MIL - STD - 781, Test Plan IV, except that the total test time shall be in multiples of the specified MTTF of this specification.

5. PREPARATION FOR DELIVERY.

5.1 Packaging. Packaging of the multiplier shall be in accordance with the best commerical practice.

6. NOTES.

6.1 Intended Use. The multiplier is intended for use in power supplies for image intensifier tubes.

6.2 Ordering Data. Procurement documents shall specify the following:

6.2.1 Specification. Title, number, revision, and date of this specification and any amendments thereto.

6.2.2 Packaging. Level of packaging and level of packing required for shipment.

6.2.3 Confirmatory Samples. If confirmatory samples are to be procured and the quantity if other than fifty (50).

6.2.4 Quantity. The quantity of multipliers to be supplied.

6.2.5 Lot Size. The quantity of multipliers making up the lot size on which sampling is based if different from confirmatory sample or quality conformance requirements.

6.3 Definitions:

6.3.1 Multiplier Efficiency. Multiplier efficiency is defined as:

$$\frac{\text{Multiplier Output Voltage}}{\text{AC Input Voltage X No. Stages}}$$

6.3.2 Damage. Damage is defined as any breakage, loosening, shift, deformation, failure of any finish, hardware, connection or component, increase or fluctuation in input current, corona, arcing, voltage instability, electrical failure of malfunctioning, or any deterioration quality, or failure to operate in accordance with the requirements of this specification.

6 STAGE MULTIPLIER MODULE CIRCUIT

FIGURE I

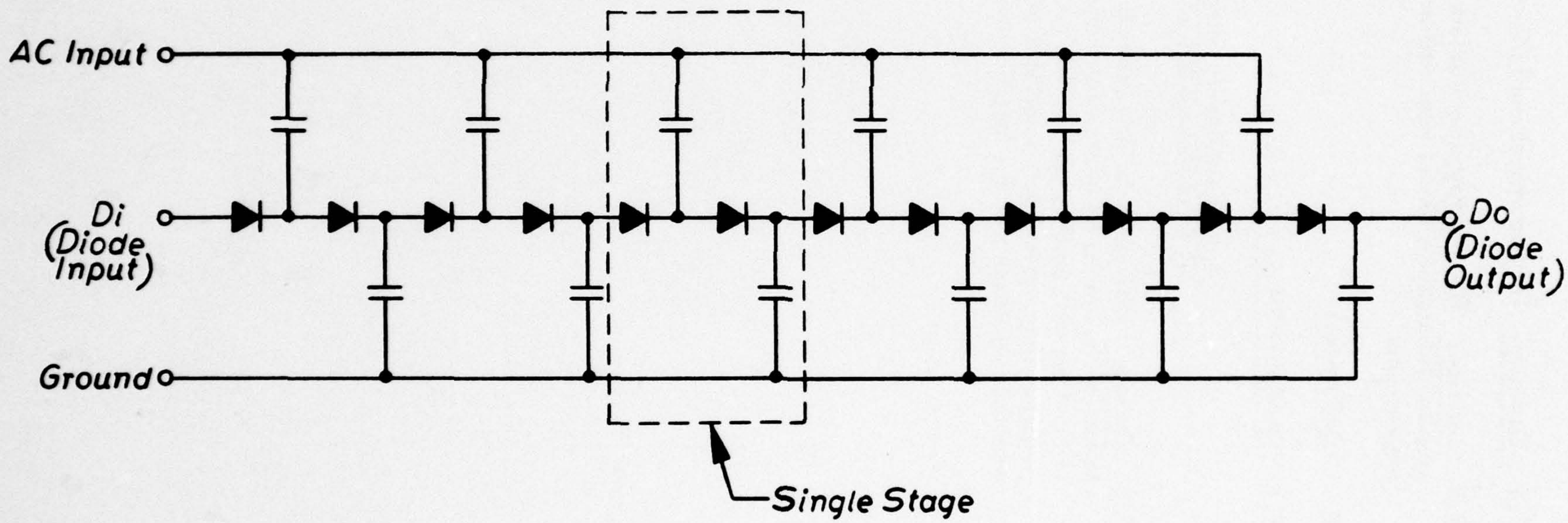
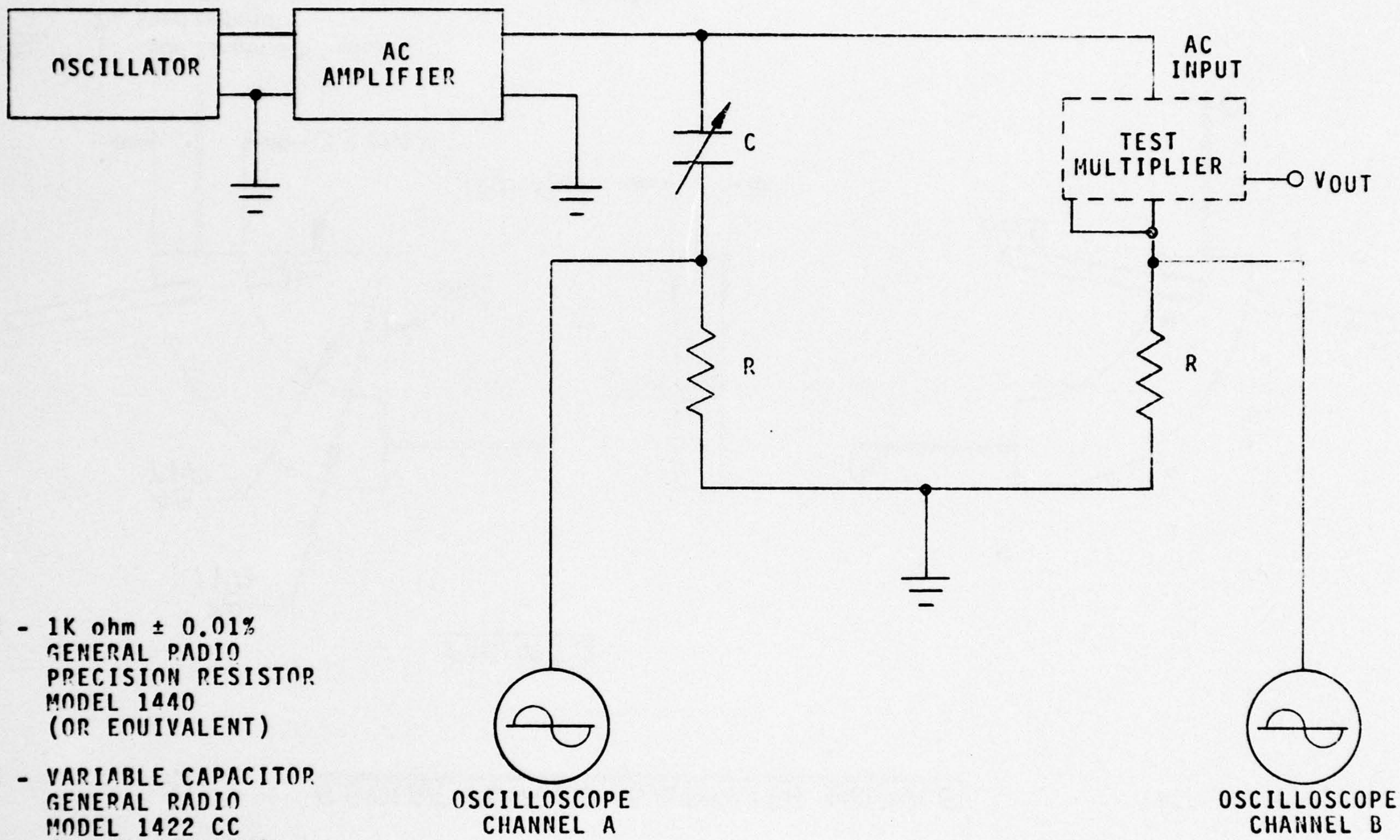


FIGURE 1

TEST CIRCUIT FOR INPUT CAPACITANCE AND CHARGING CURRENT



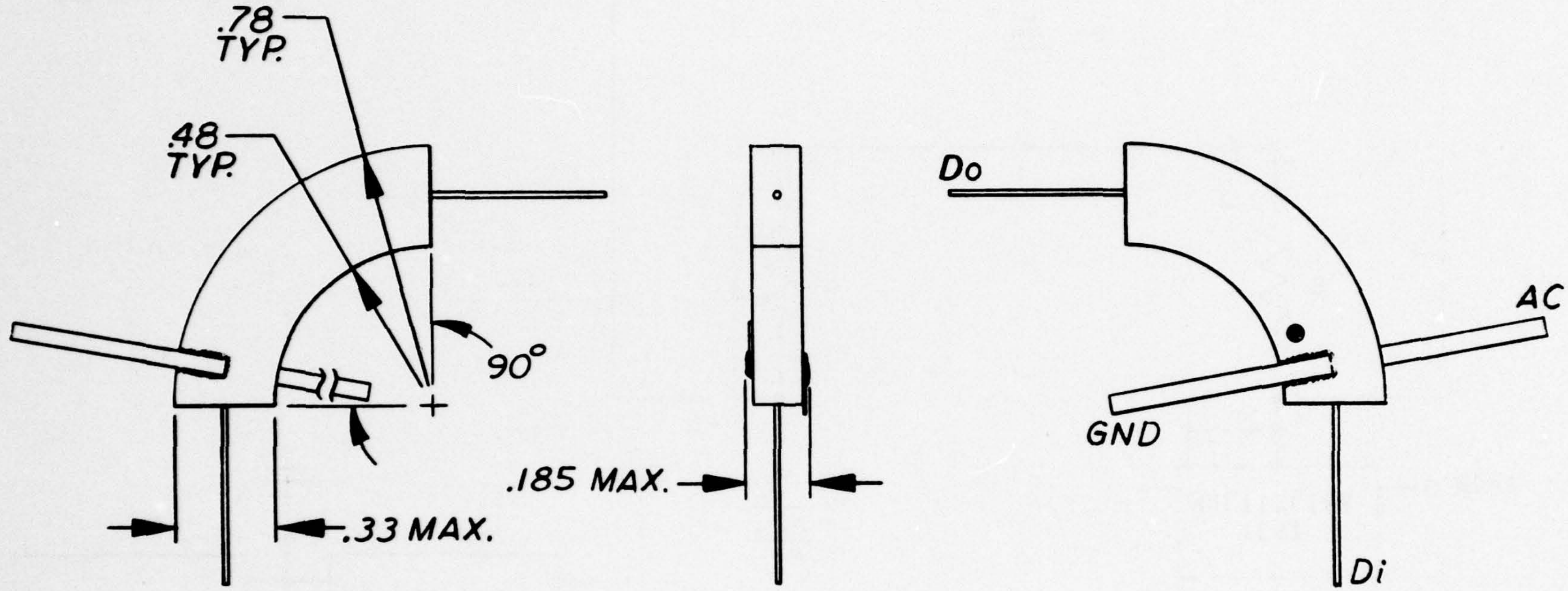
R - 1K ohm ± 0.01%
GENERAL RADIO
PRECISION RESISTOR
MODEL 1440
(OR EQUIVALENT)

C - VARIABLE CAPACITOR
GENERAL RADIO
MODEL 1422 CC
(OR EQUIVALENT)

FIGURE 2

6 STAGE CURVED MULTIPLIER MODULE

FIGURE 3



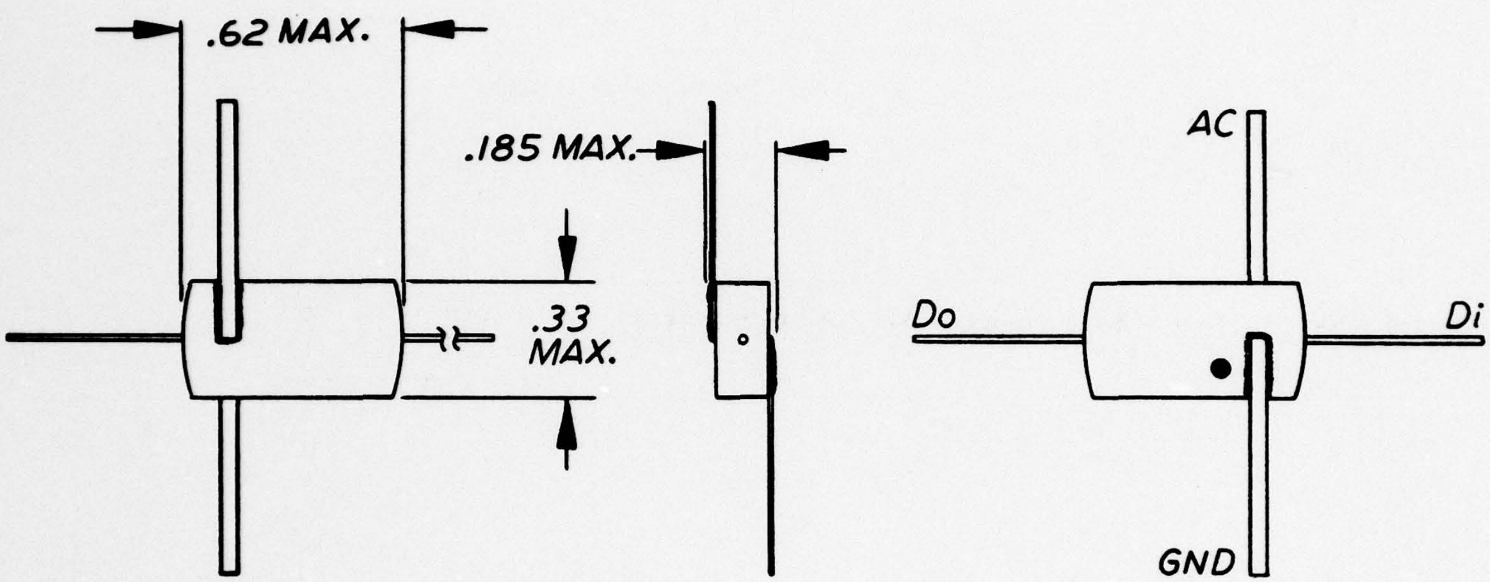
NOTE:

1. Lead Length 0.5" min.
2. Lead material
   - 2.1 D_i and D_o leads: tinned copper AWG# 28
   - 2.2 AC and ground - silver or tinned copper ribbon 0.050" x 0.005"
3. Marking: ground lead marked with colour dot

FIGURE 3

6 STAGE RECTANGULAR MULTIPLIER MODULE

FIGURE 1



NOTE:

1. Lead Length 0.5" min.
2. Lead material
   - 2.1 D_i and D_o leads: tinned copper AWG#28
   - 2.2 AC and ground - silver or tinned copper ribbon 0.050" x 0.005"
3. Marking: ground lead marked with colour dot

FIGURE 4

APPENDIX B

FAILURE ANALYSIS REPORT

Circulation:

M. Pawlowsk

FAILURE ANALYSIS REPORT

ERIE TECHNOLOGICAL PRODUCTS

F. A. No.: 1126

Date: 10 May/78

HIGH VOLTAGE PRODUCTS

ERIE

General Data

Customer: Erie Life Test Evaluation   Part Number: Curved Multiplier

Item Description: Miniature High Voltage Hybrid Multiplier Module

Erie Part No.: TSK-313-000   Specification: SCS-495, Para 4.5.17

Lot or Serial No.: 6A, 9, 18 & 7   Ref. Documents: Fort Monmouth DAA07-76-C-0041

Description of Failure Mode: Test Cond.: 1500 Vp/p @ 20 KHz, +50°C, 500 nA Load

6A - Failed after 48 Hrs. on test - Low output volt. 5.4 KVdc (Typ. 6.4 KVdc)

9 - Failed after 898 Hrs. on test - No output voltage (Typ. 6.4 KVdc)

#18 - Failed after 898 Hrs. on test - No output voltage (Typ. 6.4 KVdc)

7 - Failed after 1282 Hrs. on test - Low output volt. 5.35 KVdc (Typ. 6.4 KVdc)

Failure Analysis

Dissection Analysis:

No's. 6A & 7: The loss of one multiplier doubler stage was attributed to an open electrical connection between a rectifier, assembled in the substrate and a bank capacitor's silvered electrode termination. Evidence of severe H. V. arcing as demonstrated by the attached photo (Exhibit "A") indicates that this increased charge current caused electrical degradation of the bond between the rectifier and capacitor.

No. 9: The "No output voltage" condition was the result of a electrical short circuit with-in the multiplier. H. V. arcing at the output end of the multiplier tracked around the edge of the capacitor causing carbonization of both the capacitor and diode substrate. (NOTE: See attached photo - Exhibit "B")

No. 18: Failure analysis was not possible because the multiplier module was completely destroyed - total carbonization.

Attachments: Photo's [XX] Page 2   X-Ray's [ ]   Additional Sheets [XX]

Recurrance Control

Corrective Action:

The high voltage arcing & tracking phenomenon as demonstrated by the above failures leads us to the following conclusion. This mult. design will not withstand continuous operation with a 115 % overvoltage applied without additional encapsulation. Future life testing will be restricted to mult's. that are encapsulated in a manor that simulates "device application".

5 FRASER AVENUE, TRENTON, ONTARIO, CANADA
PHONE (613) 392 2581 · TELEX 06-62242
K8V 5S1

Analysed By: D. Archard   Approved By: D. Platt

F.A. # 1126

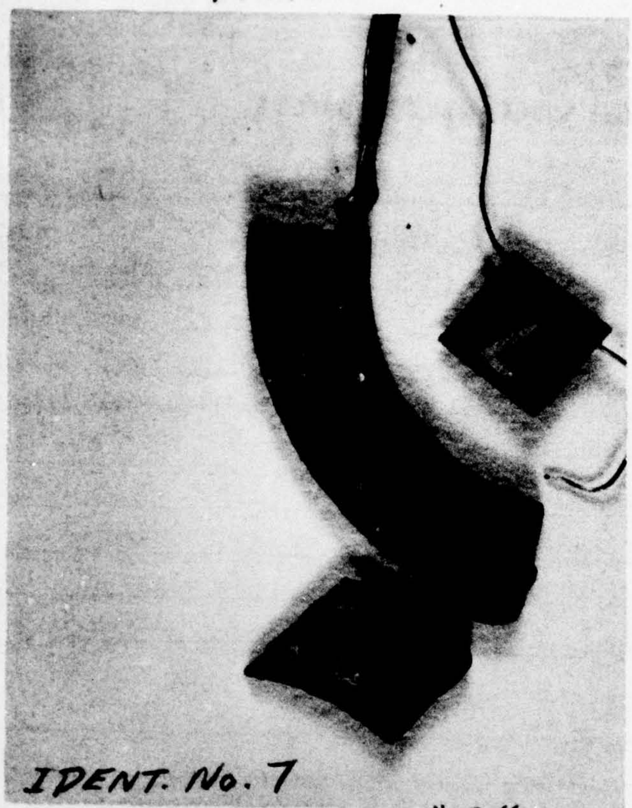


EXHIBIT "A"

F.A. # 1126

EXHIBIT "B"

Circulation:	
M. Pawlowski	

FAILURE ANALYSIS REPORT

ERIE TECHNOLOGICAL PRODUCTS OF CANADA LIMITED

F. A. No.: 1127

Date: 10 May/78

HIGH VOLTAGE PRODUCTS

ERIE

General Data

Customer: Erie Life Test Evaluation

Part Number: Rectangular Mult.

Item Description: Miniature High Voltage Hybrid Multiplier Module

Erie Part No.: TSK-312-000

Specification: SCS-495, Para 4.5.17

Lot or Serial No.: 11A

Ref. Documents: Fort Monmouth DAA07-76-C-0041

Description of Failure Mode: Test Cond.: 1150 Vp/p @ 20 KHz, +50°C, 500 nA Load

#11A - Failed after 696 Hrs. on test - Low output volt. 5.4 KVdc (Typ. 6.4 KVdc)

Failure Analysis

Analysis Procedures and Results:

The multiplier has experienced an increase in "contact resistance" due to deterioration of the electrical bond between the individual diodes and bank capacitor terminations. The resistance increase has caused a loss in multiplier efficiency and therefore has resulted in a low output voltage level.

Attachments: N/A Photo's ☐ X-Ray's ☐ Additional Sheets ☐

Recurrance Control

Corrective Action:

The bonding agent between the diode leads and the silvered capacitor pads (Epo-Tek 410) is applied as a very thin coating and perhaps the conductive properties are changing as a result of long term exposure to temperature and voltage potential.

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