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CONFORMAL COATINGS FOR PRINTED CIRCUIT ASSEMBLIES

REPORT NO. 5

DA-36-039-sc-89136

FIFTH QUARTERLY REPORT

JULY 16, 1962 TO OCTOBER 31, 1962

U. S. ARMY SIGNAL SUPPLY AGENCY
STANDARDIZATION ENGINEERING DIVISION
FT. MONMOUTH, NEW JERSEY

MOTOROLA INC.
Military Electronics Division · Chicago Center
1450 NORTH CICERO AVENUE, CHICAGO 51, ILLINOIS

CONFORMAL COATINGS

FOR

PRINTED CIRCUIT ASSEMBLIES

Fifth Quarterly Report for the period of July 16, 1962 to October 31, 1962.

Signal Corps Contract Number DA 36-039 SC89136

Department of the Army Project Number: 5999-004

Placed by: United States Army Electronics Material Support Agency
Standardization Engineering Division
Fort Monmouth, New Jersey

Contractor: Motorola, Inc.
Chicago Center
1450 N. Cicero Ave.
Chicago 51, Illinois

Signal Corps Contract Number DA-36-039 SC-89136

Technical Requirements for PR & C Number 61-SIMSA-482 dated 22 March 1961.

Dept. of the Army Project Number 5999-004

Report Submitted by: Anthony Beccasio
Anthony J. Beccasio
Project Engineer

Report Approved by: Robert D Andreason
Robert Andreason
Manager, Engineering Services

CONFORMAL COATINGS FOR

PRINTED CIRCUIT ASSEMBLIES

Fifth Quarterly Report for the period of July 16, 1962 to October 31, 1962.

Objective:

Phase A: (a) Evaluate commercially available conformal coating materials used as protective coatings on printed circuit boards in order to obtain data for the preparation of a three services coordinated military specification which will provide sufficient physical, mechanical and electrical properties to assure satisfactory performance of printed circuit assemblies over long storage periods and under high humidity conditions.

(b) Study the effect of thickness of coatings on Insulation Resistance and "Q" factor,at 1,50 and 100mc, under humidity conditions.

Phase B: Investigate a method of removing the coating from the board to permit replacement of parts when necessary without impairing the functional operations of the unit.

Phase C: Evaluate, for possible upgrading purposes, allowable minimum spacings between conductors on uncoated and coated boards as described in paragraphs 5.1.5 of MIL-STD-275A.

Phase D: Study effects of coatings on copper, gold and solder-plated conductors with respect to their effect on "Q" factor and capacity at 1, 50 and 100 mc using various spacings and configuration (consideration should be given to the spacings shown in paragraph 5.1.5 of MIL-STD-275): (See Phase C). Specimens shall consist of single and double sided 1/16" copper clad glass epoxy laminates and uncoated controls. The parameters to be considered shall include, but not be limited to, the following:

(a) Width of conductors
(b) Length of Parallel conductors
(c) Plating thickness
(d) Spacing of conductors

Phase E: The information resulting from Phases A, B, C and D shall be used as a basis for redesign of the following AN/VRC-12 printed wiring boards to accept a conformal coating with minimum changes in physical and electrical characteristics of the boards. All changes in design shall be approved by the project engineer.

Objective Phase E (Cont.)

Part Number	Part Name
63-50118	Antenna Assembly
63-50122	Second RF Assembly
63-50120	First RF Assembly
63-50124	Mixer Assembly
63-50130	Oscillator Assembly
63-50126	Oscillator Assembly
63-50132	Buffer Assembly

NOTE: The above boards, with associated schematic diagrams and applicable specifications, will be furnished by the Government.

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APPENDIX

PURPOSE

PHASE A

SECTION 1

Evaluate commercially available conformal coating materials used as protective coatings on printed circuit boards in order to obtain data for the preparation of a three services coordinated military specification which will provide sufficient physical, mechanical and electrical properties to assure satisfactory performance of printed circuit assemblies over long storage periods and under high humidity conditions.

Stage A

Investigation of two component epoxy resin conformal coatings on XXXP, glass-epoxy and paper-epoxy copper clad laminate series specified in MIL-P-13949B and PR & C 61-SIMSA-482.

Task 1 Two-part epoxy resin coating systems.

- Part 1 Characteristics of epoxy resin coatings studied.
- Part 2 Curing Schedule.

Task 2 Test Panels used.

Task 3 Precoating Preparation of Surface.

- Part 1 Cleaning.
- Part 2 Soldering.

Task 4 Method of Coating Application.

Task 5 Physical and Electrical Properties of Epoxy Resin Coating Systems.

- Part 1 Appearance and Adhesion.
- Part 2 Thickness measurements.
- Part 3 Dielectric Constant and Dissipation Factor of disc specimens.
- Part 4 Dissipation Factor and Q-Factor of coated test panels.
- Part 5 Dielectric Withstanding Voltage (initial).
- Part 6 Thermal cycling.
- Part 7 Dielectric Withstanding Voltage (after thermal cycling).
- Part 8 Insulation resistance and appearance under moisture conditions.

Part 9 Dielectric Withstanding Voltage (after moisture test).

Part 10 Abrasion Resistance.

Part 11 Ruggedization.

Part 12 Flexibility.

Stage B

Investigation of polyurethane resin conformal coatings on XXXP and glass-epoxy, copper-clad laminate series specified in MIL-P-13949B and PR & C 61-SIMSA-482.

Tasks 1 - 5 The same as Stage A where application is feasible.

Stage C

Investigation of Silicone-based polymer coatings on glass-epoxy and silicone-glass copper-clad laminate series specified in MIL-P-13949B.

Stage D

Investigation of MIL-V-173 varnishes on glass-epoxy, XXXP and paper-epoxy laminates per MIL-P-13949B.

Tasks 1 - 5 The same as Stage A where application is feasible.

Stage E

Investigation of one component epoxy coating compounds on Type GB glass-epoxy laminate specified in MIL-P-13949B.

Tasks 1 - 5 The same as Stage A where application is feasible.

Stage F

Investigation of acrylic coating compounds on Type GB glass-epoxy laminate specified in MIL-P-13949B.

Tasks 1 - 5 The same as Stage A where application is feasible.

Stage G

Investigation of polystyrene based-coatings on Type GB glass-epoxy laminates specified in MIL-P-13949B.

Tasks 1 - 5 The same as Stage A where application is feasible.

SECTION 2

Study the effects of thickness of coating on insulations resistance and "Q"-factor under prolonged humidity conditions.

Task 1 Test panels used.

Task 2 Precoating preparation of surface.

Task 3 Method of application and thickness of coating.

Task 4 Q-factor of coated panels.

Task 5 Insulation resistance under moisture conditions of coated test panels.

PHASE B

Investigate a method of removing the coating from the board to permit replacement of parts when necessary, without impairing the functional operations of the unit.

Stage A

Investigation of chemical stripping of conformal coating as a method of repairing printed wiring assembly.

Stage B

Investigation of mechanical stripping of conformal coating as a method of repairing printed wiring assembly.

PHASE C

Evaluate, for possible upgrading purposes, allowable minimum spacings between conductors on coated and uncoated boards as described in paragraphs 5.1.5 of MIL-STD-275A.

PHASE D

Study the effects of coatings on copper, gold and solder-plated conductors with respect to their effect on "Q" factor and capacity at 1, 50 and 100 mc

Stage A Width of conductors.

Stage B Length of parallel conductors.

Stage C Plating thickness.

Stage D Spacing of conductors.

Phase E

Using Phases A, B, C and D as a basis, investigate the following AN/VRC-12 printed wiring boards to accept a conformal coating with minimum changes in physical and electrical characteristics of the assembly.

Stage A - Antenna Board Assembly.

Stage B - Second R.F. Assembly.

Stage C - First R.F. Assembly.

Stage D - Mixer Assembly.

Stage E Tuner Oscillator Assembly.

Stage F - Oscillator Assembly.

Stage G - Buffer Assembly.

ABSTRACT

PHASE A

SECTION 1

Stages E, F and G

Investigation of one-component epoxy, acrylic, and polystyrene-based coating compounds for use as conformal coatings on Type GB glass-epoxy laminate specified in MIL-P-13949B.

Task 1 - One Component Epoxies, Acrylic and Polystyrene Coating Systems.

Part 1 Characteristics of Coating Systems Studied

The one-component epoxy, acrylic and polystyrene-based coating systems studied met the requirements of para. 2b of PR & C 61-SIMSA-482 as to method of application, transparency and curing time.

Part 2 Curing Schedule

All coating was cured at room temperature for 4 hours.

Task 2 - Test Patterns Used.

The test patterns used were etched on Type GB glass-epoxy laminate and fabricated in accordance with Figure 1, Note 7 of MIL-P-55110.

Task 3 - Precoating Preparation of Surface

Part 1 Cleaning

To eliminate all corrosion effects other than those from the testing or the coating itself, a stepwise cleaning technique for the surface of the specimen panel was devised. Unless otherwise indicated, the complete outlined technique was used.

Task 4 - Method of Coating Application

All specimen panels were brush coated.

Task 5 - Physical and Electrical Properties of One-Component Epoxy, Acrylic and Polystyrene Coating Systems.

Part 1 Appearance and Adhesion

A visual cheek of the coated test panels revealed no evidence of blistering, wrinkling, cracking and peeling of coating and no corrosion of printed conductors. All coatings showed good adhesion to specimen test panels.

SECTION 2

Study the effects of the thickness of coatings on insulation resistance and Q-factor under prolonged humidity conditions.

Task 1 - Test Patterns Used

The test patterns used were etched on Type GB glass-epoxy laminate and fabricated in accordance with Fig. 1, Note 7 of MIL-P-55110.

Task 2 - Precoating Preparation of Surface

The same procedure described in Task 3 of Stages E, F and G was followed.

Task 3 - Method of Application and Thickness of Coatings

The various thickness of coatings to be tested were applied to the specimen test panels using the Gardner Ultra Applicator, made by Gardner Laboratory, Bethesda, Maryland. The thickness of the coatings will be measured using a dial micrometer accurate to ± 0.0001 inches.

PHASE D

Study the effects of coatings on copper, gold and solder-plated conductors with respect to their effect on "Q" factor and capacity at 1, 50 and 100mc.

Stages A,B,C,D - width of conductors, length of parallel conductors, plating thickness and spacing of conductors.

The test patterns for these stages are fabricated or are in the process of fabrication.

Publications, Lectures, Reports and Conferences

On July 30 and 31, 1962, the writer visited the Signal Corps to discuss the results obtained and described in Quarterly Report No. 4 and also discuss the plan of attack for the new contract.

On September 4 and 5, 1962, Mr. A.Z. Orlowski of the Signal Corps visited Motorola, Incorporated to discuss and view the progress of the program.

On October 4 and 5, 1962, the writer visited Mr. R.E. Martz of the Naval Avionics Facility, Indianapolis, Indiana to discuss our results of Phase C of the program.

On October 23 and 24, 1962, the writer visited the Signal Corps to discuss the progress of the program and also demonstrate for Signal Corps personnel, the repair procedures that were derived from Phase B of the contract.

FACTUAL DATA

Phase A

Section 1

Stages E, F and G

Investigation of one-component epoxy, acrylic and polystyrene-based coating compounds for use as conformal coatings on Type GB glass-epoxy laminate specified in MIL-P-13949B.

Task 1 - One Component Epoxy, Acrylic and Polystyrene Coatings

Part 1 - Characteristics of Coating Systems Studied

The coating materials to be studied were carefully screened so that they met the following properties:-

(a) Suitability for dip, spray or brush coating application.
(b) Transparency of coating when fully cured.
(c) Cure time not to exceed 75°C for a two hour period.
(d) Coating formulation not to support fungus growth.

Part 2 - Curing Schedule

Acrylic and polystyrene coating were cured at room temperature for 24 hours. The epoxy coating was cured at 75°C for 2 hours.

Task 2 - Test Pattern Used

The test pattern used for evaluating these coatings was the two parallel line pattern fabricated in accordance with Figure 1, Note 7 of MIL-P-55110 and etched on 0.062 inch thick, two ounce, copper clad, Type GB glass-epoxy laminate per MIL-P-13949B.

A diagram of this test pattern appears in the Appendix, page i

Task 3 - Precoating Preparation of Surface

Part 1 - Cleaning

The following cleaning technique was followed so as to eliminate as nearly as possible all surface contaminates that would tend to cause corrosion. Panels are prepared for testing using the following cleaning method:

(a) Etched side of boards are abraded with a fine grade of steel wool.
(b) Leads are soldered to terminal points using 60-40 flux core solder.
(c) Soldered panels are scrubbed in isopropyl alcohol to remove the rosen flux and other contaminates.
(d) The panels are air dried and then coated.

Task 4 - Method of Coating Application

The coating material was brushed on the etched side of the laminate and was cur d in a horizontal position so that an even surface coat was obtained.

Task 5 - Physical and Electrical Properties of One Component Epoxy, Acrylic and Polystyrene Coating Systems.

Part 1 - Appearance and Adhesion

After the panels were coated and cured, they were examined, visually, for evidence of blistering, wrinkling, cracking and peeling of the coating and corrosion of the conductors.

Section 2

Study the effect of the thickness of coatings on insulation resistance and Q-factor under prolonged humidity conditions.

Task 1 - Test Pattern Used

The test pattern and laminate used is similar to that described in Task 2, Section 1 of Phase A.

Task 2 - Precoating Preparation of Surface

The same procedure outlined in Task 3, Section 1 of Phase A was followed.

Task 3 - Method of Application and Thickness of Coatings.

The various thicknesses to be investigated were applied to three of the test panels using a Gardner Ultra Applicator, manufactured by the Garnder Labs, Bethesada, Maryland.

Phase D

Study the effects of coatings on copper, gold and solder-plated conductors with respect to their effect on "Q" factor and capacity at 1,50 and 100mc.

Stages A,B,C,D, - width of conductors, length of parallel conductors, plating thickness and spacing of conductors.

The test patterns for these stages are in the process of being fabricated.

A diagram of the test patterns to be evaluated is shown in the Appendix, page ii.

To study the distributed capacity of these patterns, these oscillators have been built, the circuit diagrams for the 1,50 and 100mc appears in the Appendix, pages iii, iv and v.

The Q-factor of these patterns will be measured at 1,50 and 100mc on Booton Radio Company Q meters. For frequencies below 20 mc, Model 260-A Q meter will be used, whereas for frequencies above 20 mc. the Model 190-A Q-meter will be used.

CONCLUSION

Phase A

Section 1

Stages E,F, and G

Investigation of one-component epoxy, acrylic and polystyrene-based coating compounds for use as conformal coatings on Type GB glass-epoxy laminate specified in MIL-P-13949B.

Task 1 - One Component Epoxy, Acrylic and Polystyrene Coatings.

Part 1 - Characteristics of Coating Systems Studied.

All the coatings met the following characteristics:-

(a) Suitability for dip, brush or spray coat application.
(b) Transparency when fully cured.
(c) Cure time not to exceed 75°C for 2 hours.
(d) Coating formulation does not support fungus growth.

Part 2 - Curing Schedule

Epoxy coating was cured at 75°C for 2 hours whereas the acrylic and polystyrene coatings were cured at room temperature for 24 hours.

Task 2 - Physical and Electrical Properties of One Component Epoxy, Acrylic and Polystyrene Coating Systems.

Part 1 - Appearance and Adhesion

All coated test panels exhibited no blistering, wrinkling, cracking or peeling of coating and no corrosion of printed conductors. All coatings exhibited good adhesion to the test panel.

Section 2

Study the effect of the thickness of coatings on insulation resistance and Q-Factor under prolonged humidity conditions.

Task 3 - Method of Application and Thickness of Coatings

By using the Gardner Ultra Applicator, a consistent coating thickness was obtained.

Program for the Next Quarter

(1) Complete effect of thickness of coating on insulation resistance and Q-factor under prolonged humidity study.

(2) Begin Phase D.

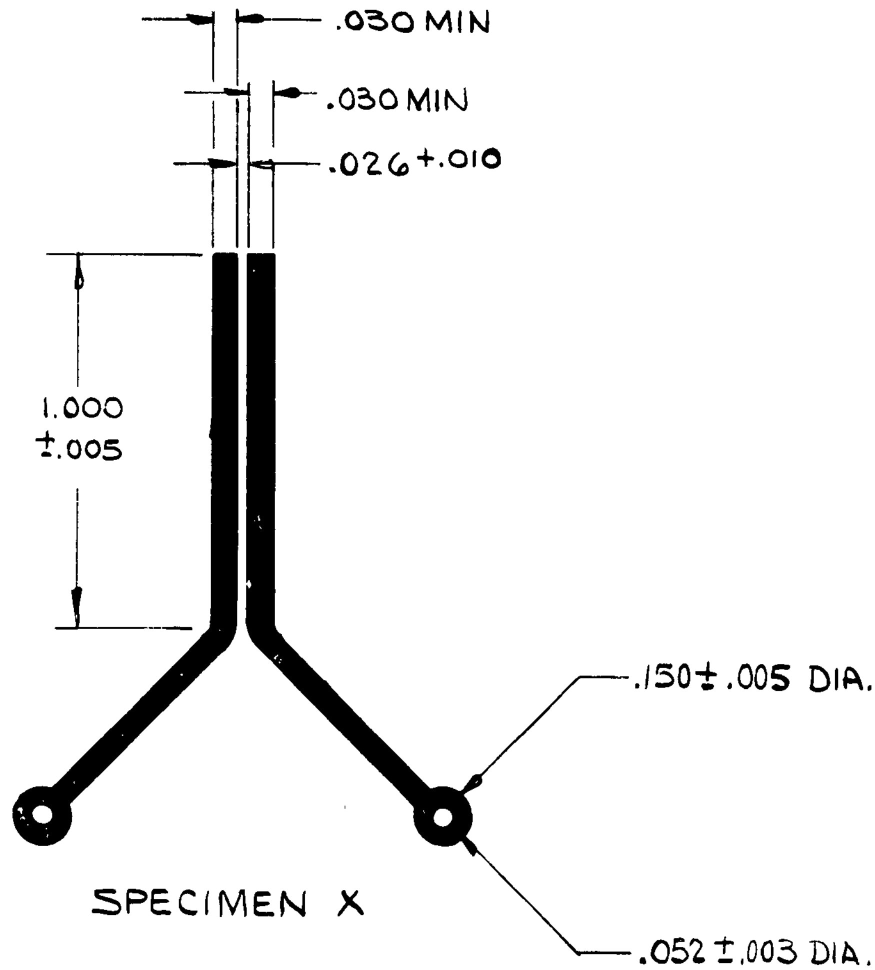
(3) Complete Phase A, section 1, Stages E,F, and G study.

Identification of Key Personnel

	Time Spent - Hours
Mr. Anthony Beccasio Project Engineer	304
Mr. Arthur Aerne Electrical Engineer	23
Mr. Andrew Francis Technician	114
Mr. Robert Sobol Technician	44
Total	485

A P P E N D I X

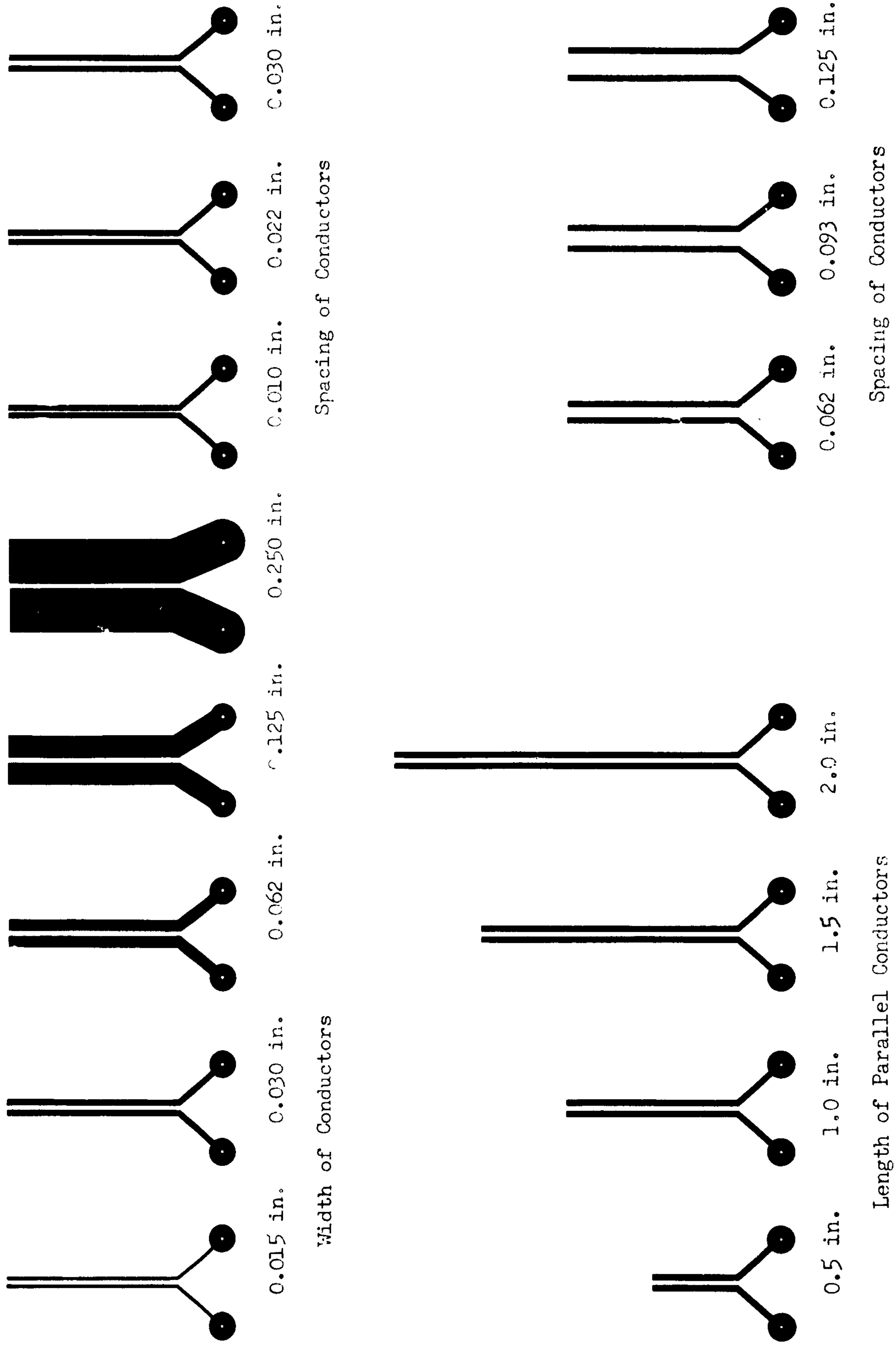
TABLE I



PHASE A TEST PATTERN

TABLE II

PHASE D TEST PATTERNS



1mc Oscillator

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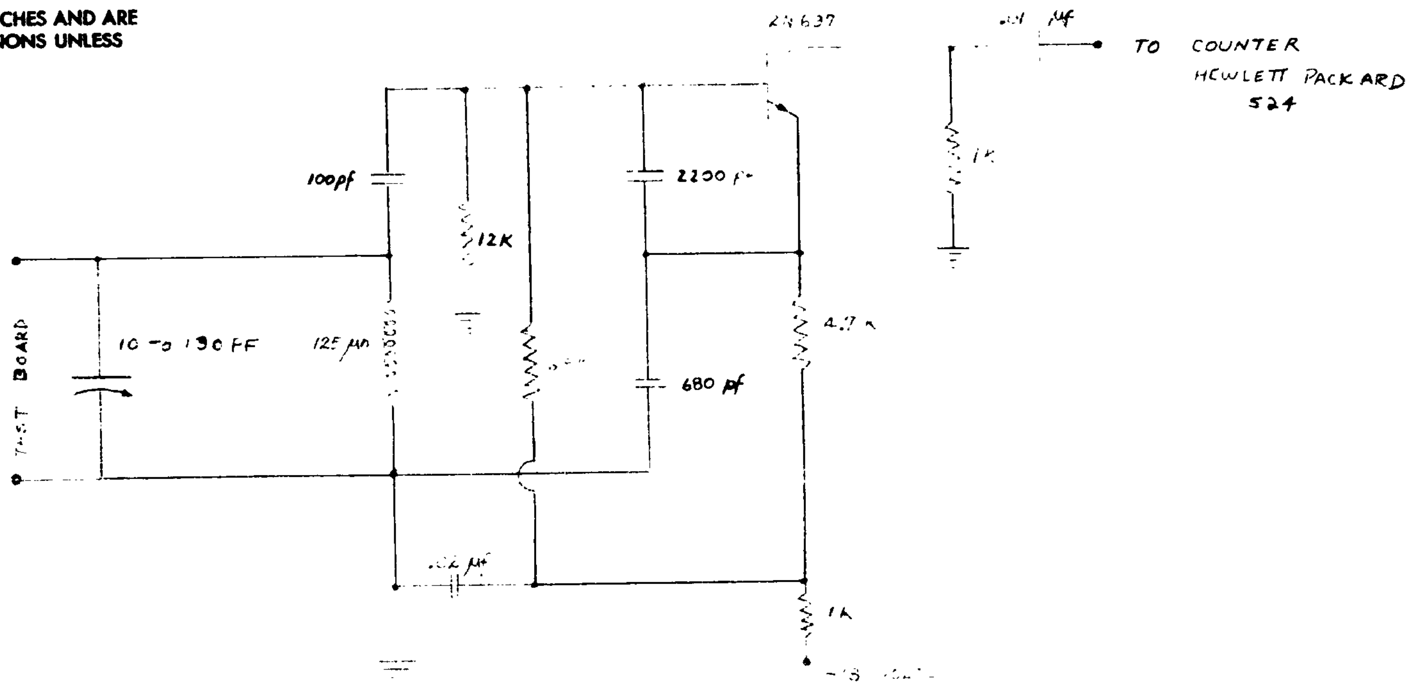

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*MOTOROLA APPLICATION		APPLICATION	

TOLERANCES UNLESS OTHERWISE SPECIFIED
TWO PLACE DEC ± ANGULAR DIM. ±
THREE PLACE DEC ± HOLE DIM. ±
MATERIAL
FINISH

DR BY
CHK BY
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M ENG
SPEC
R & C
RELEASE MEMO

MOTOROLA INC.
ORDER NO.
SIGNAL CORPS
REVIEWED
APPROVED
DATE

1 Mc. OSCILLATOR

SCALE

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U. S. ARMY SIGNAL MATERIEL SUPPORT AGENCY
FORT MONMOUTH NEW JERSEY

CODE 80063

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50mc Oscillator

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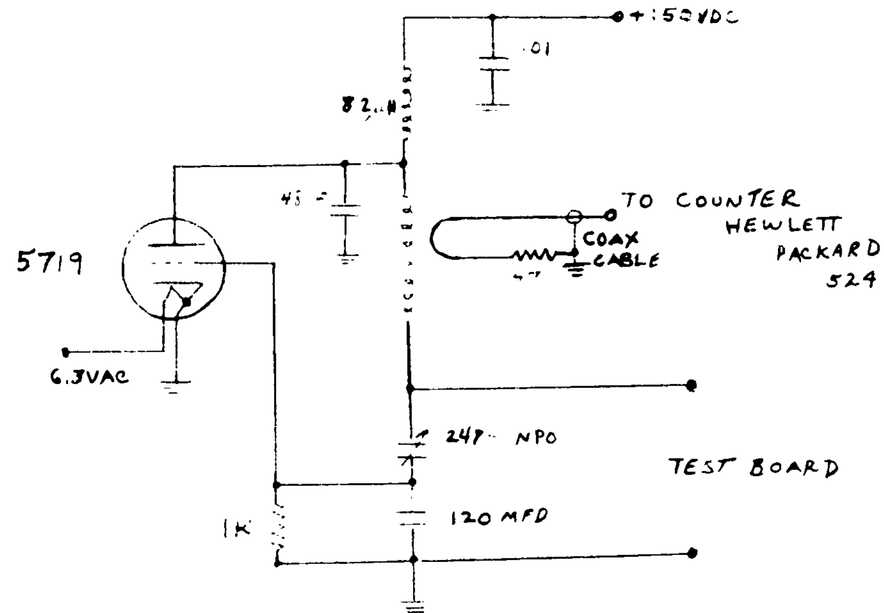

				TOLERANCES UNLESS OTHERWISE SPECIFIED TWO PLACE DEC ± ANGULAR DIM. ± THREE PLACE DEC ± HOLE DIM. ±	DR BY	MOTOROLA INC.	50 MC OSCILLATOR
				MATERIAL	CHK BY E ENG M ENG SPEC R & C	ORDER NO. SIGNAL CORPS REVIEWED APPROVED	DEPARTMENT OF THE ARMY U. S. ARMY SIGNAL MATERIEL SUPPORT AGENCY FORT MONMOUTH NEW JERSEY
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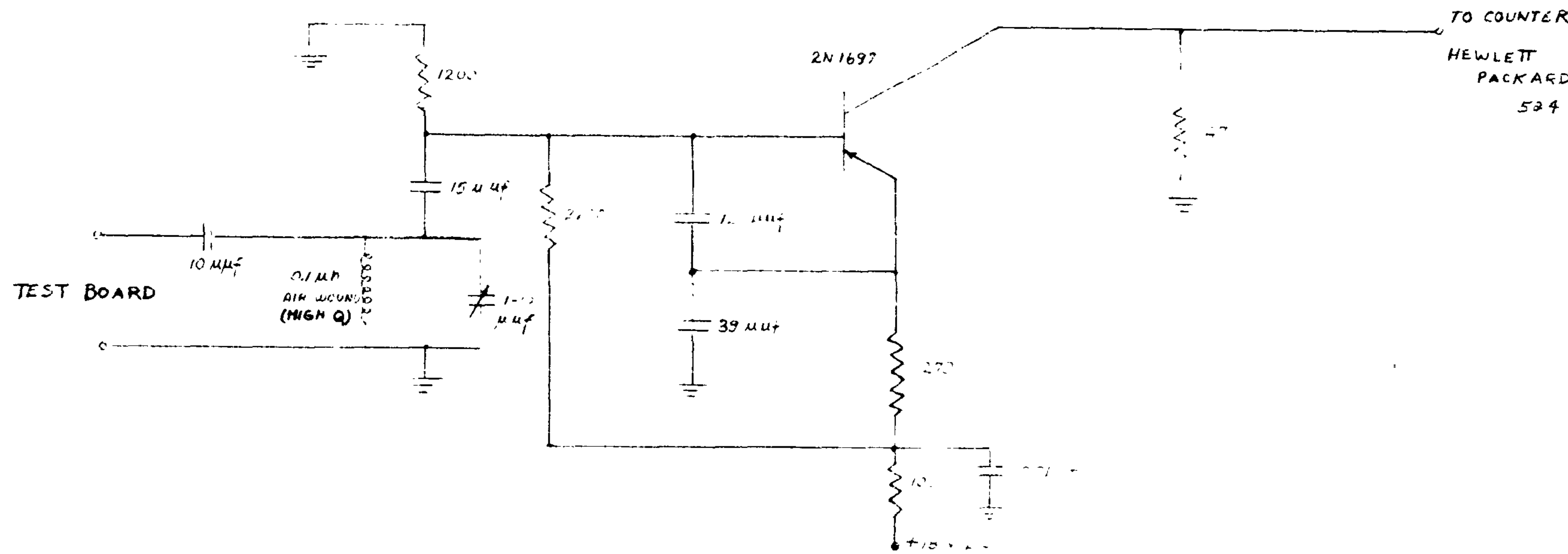

100mc Oscillator

TOLERANCES UNLESS OTHERWISE SPECIFIED	
TWO PLACE DEC ±	ANGULAR DIM. ±
THREE PLACE DEC ±	HOLE DIM ±
MATERIAL	
FINISH	

DR BY
CHK BY
E ENG
M ENG
R & C

MOTOROLA INC.
ORDER NO.
SIGNAL CORPS
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100 Mc OSCILLATOR

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