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STATIC-ELECTRICITY ANALYSIS PROGRAM

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This volume, (Volume II) the Users Manual, describes the implementation of the computer program entitled PSTAT. PSTAT is based upon the theoretical and experimental work developed in the companion volume entitled "Static-Electricity Analysis Program (Volume I)".

Volume I details the methodology used to model various aspects of p-static and streamering, while Volume II describes the specifics needed to run program PSTAT.

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LIST OF FIGURES

LIST OF VARIABLES USED IN P-STAT

NSECT:	An integer variable specifying the program option to be used (corona noise or streamer noise).
LA:	An integer variable specifying the antenna location.
LANT:	An alphanumeric variable describing the antenna location.
NCOUP:	An integer variable specifying the number of coupling coefficients to be read from data cards.
ESTO:	A floating point array containing the NCOUP antenna-elevator coupling coefficients.
WSTO:	A floating point array containing the NCOUP antenna-wing coupling coefficients.
RSTO:	A floating point array containing the NCOUP antenna-rudder coupling coefficients.
NRUN:	An integer variable specifying the number of program cycles to be made using the same coupling coefficients.
IOFF:	An integer variable specifying the locations of the p-static discharges which are to be considered "quiet".
IT:	An alphanumeric variable describing the type of aircraft under investigation.
XN:	A floating point variable specifying the size of the aircraft relative to a KC-135.
SPD:	A floating point variable specifying the aircraft speed.
ALT:	A floating point variable specifying the aircraft altitude.
MODEF:	An integer variable specifying the frequency select mode the user wishes to use (uniform or non-uniform frequency intervals).
FSTRT:	(If MODEF equals 0) A floating point variable specifying the desired starting frequency (in MHz).
FSTP:	(If MODEF equals 0) A floating point variable specifying the desired stopping frequency (in MHz).
FDEL:	(If MODEF equals 0) A floating point variable specifying the frequency increment between FSTRT and FSTP (in MHz).

NFR: (If MODEF does not equal 0) An integer variable specifying the number of user-selected frequencies to be read in from cards.

FREQU: (If MODEF does not equal 0) A floating point variable specifying the user-selected frequency (in MHz). The maximum number of FREQU cards allowed is 90.

AANT: A floating point variable specifying the antenna induction area (in square meters).

BNDW: A floating point variable specifying the receiver bandwidth (in kHz).

ICLO: An integer variable specifying the type of cloud the aircraft is flying through.

IC: An alphanumeric variable describing the type of cloud the aircraft is flying through.

(Variables Used Only in Streamer-Noise Calculations)

IM: An integer variable specifying the type of dielectric material being charged.

IMAT: An alphanumeric variable describing the type of dielectric material being charged.

DAFT: A floating point variable specifying the distance (in meters) the receiving antenna is located behind the windshield canopy or the radome.

WX: A floating point variable specifying the minimum characteristic dimension (in meters) of the dielectric material being charged.

DIERAT: A floating point variable specifying the ratio of the frontal area of the dielectric material to the frontal area of the aircraft.

I INTRODUCTION

When an aircraft or other flight vehicle is operated in precipitation containing ice crystals or other particulate materials, frictional electrification associated with particle impact causes the impinging particles to acquire a net charge and to deposit an equal and opposite charge on the vehicle.[1-5*] The charging occurs on the frontal metallic and dielectric portions of the vehicle.[6,7] Although the charge deposited by a single ice crystal changes the potential of the aircraft only slightly (of the order of 0.01 volt for the case of a KC-135 struck by a cirrus-cloud crystal),[4] the particle impact rate in a typical cloud is sufficient to cause the vehicle potential to reach hundreds of kilovolts in less than a second.[4]

The electrification of the vehicle is of relatively little concern in itself because the energies involved are small, and since the electrostatic fields do not penetrate to the interior. It is the consequences of the electrification that are of concern to the EMC engineer. When the vehicle potential reaches roughly 100 kV, the electric-field intensity at the aircraft extremities becomes sufficiently high that electrical breakdown of the air (corona discharge) occurs.[8] At aircraft operating altitudes, the corona breakdown from the extremities occurs not as a continuous flow of charge, but as a series of pulses with roughly 10 ns rise times and 200 ns duration and therefore generates radio noise over a broad spectrum.[4,5,8]

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[*] References are listed at the end of this Users Manual.

A similar situation exists on the dielectric frontal surfaces. As charge continues to accumulate on the dielectric, the potential to the airframe rises until the electric-field intensity at the dielectric surface becomes sufficiently high that voltage breakdown (streamer discharge) across the plastic surface occurs. A surface streamer involves the rapid transfer of charge over a substantial distance, and also generates serious radio frequency interference.[6,7]

The degree to which the radio frequency noise generated by corona and streamer discharges couples into electronic systems on the flight vehicle is determined by the relative locations of the noise source and the "antenna" via which the noise is coupled into the affected system. In addition, the coupling depends upon frequency, the size of the vehicle, and the size of the antenna.[4,5,7]

On earlier efforts, various aspects of the problem of precipitation-static noise generation and coupling were studied analytically and experimentally both in the laboratory and in flight tests. Unfortunately, the results of these efforts are spread over a large number of reports, each of which treats only a limited part of the overall problem. Thus the EMC engineer is in the position of having to be familiar with all of the publications in considerable depth if he is to apply the results of the earlier work to his problems.

In order to overcome these problems, SRI developed a computer program, entitled PSTAT, which will accurately predict the effects of p-static noise in aircraft systems. The computer program has been demonstrated to allow the EMC engineer, or systems designer, to determine the effects of p-static charging on a wide variety of aircraft types and under a wide variety of flight regimes. Since the program is based on the results of earlier experimental and analytical work, the limitations of this earlier work are reflected in the computer program. The accuracy of PSTAT depends on the modelling and on the faithfulness with which the experimental analytical data represent the true picture of p-static noise. It is felt that PSTAT is accurate to within a few percent for KC-135 type aircraft, decreasing to tens of percent for widely divergent aircraft types (delta wing fighters, for example). Although it has been possible to extend the applicability of the first-generation program described here somewhat beyond the strict confines of the earlier work, there are situations in which the program simply cannot be applied. For example, with the present program, it is not possible to consider helicopters or rockets because their geometries are radically different from aircraft.

This users manual is intended to guide the program user through the input and output requirements of the program. Sample input decks and output listings are included in this users manual to help the user understand the proper input-deck setup. Specific modeling techniques are not explained in this manual because they are fully explained in the accompanying Final Report under this contract.

The philosophy applied in creating the present program was one of simplicity. The authors felt that direct in-line coding was more appropriate to the needs of potential users than were more complicated coding techniques. In-line coding affords the non-programmer user the convenience of being able to look at the program and determine the sequence of events that have just taken place and those that are about to begin.

Extensive comments have been inserted throughout the program in order to clarify the various program steps.

II HARDWARE REQUIREMENTS AND LANGUAGE

A. Hardware Requirements

PSTAT was designed to run with a minimum computer configuration. The program uses a card reader for input and a line printer for output. No additional peripherals are required.

The program uses 5203_{10} words of core storage.

Execution time is dependent on the parameters selected during input, but typical execution times of, perhaps, 5 to 10 seconds could be expected for typical calculations, and this time would include the card read, CPU, and printer times.

It is estimated that the CPU time required for a typical run is on the order of 100 ms.

B. Language

PSTAT is written in standard ASA FORTRAN.

III COMPUTER PROGRAM

A. General

The experimental and analytical data regarding p-static noise is discussed fully in Section II of the Final Report (Vol. I) written under this contract and will not be repeated here.

The nature of the material presented in the final report was such that, in some cases, exact analytical expressions could be used in the computer program. In other cases, approximations to the desired parameters were used; and in still others, where the data did not lend themselves to approximation, the data were simply stored in tabular form.

B. Flowchart

Based on immediate needs, the requirements anticipated in the future, and information currently available, a flowchart was developed to be a guideline for the coding effort. This flowchart is shown in Figure 1.

It can be seen from this figure that the p-static program is broken into two sections, or modules. Module 1 deals with the calculation of noise generated in antennas by corona discharges from the aircraft extremities. Module 2 deals with the calculation of noise generated in antennas by surface streamer discharges across the plastic surfaces of the aircraft's radomes and canopies.

During program execution, either Module 1 or Module 2 is selected by the user by use of a data card read in as the first data card.

It can be observed from this figure that an input data error test is made only on the data input to Module 1. It was decided that the

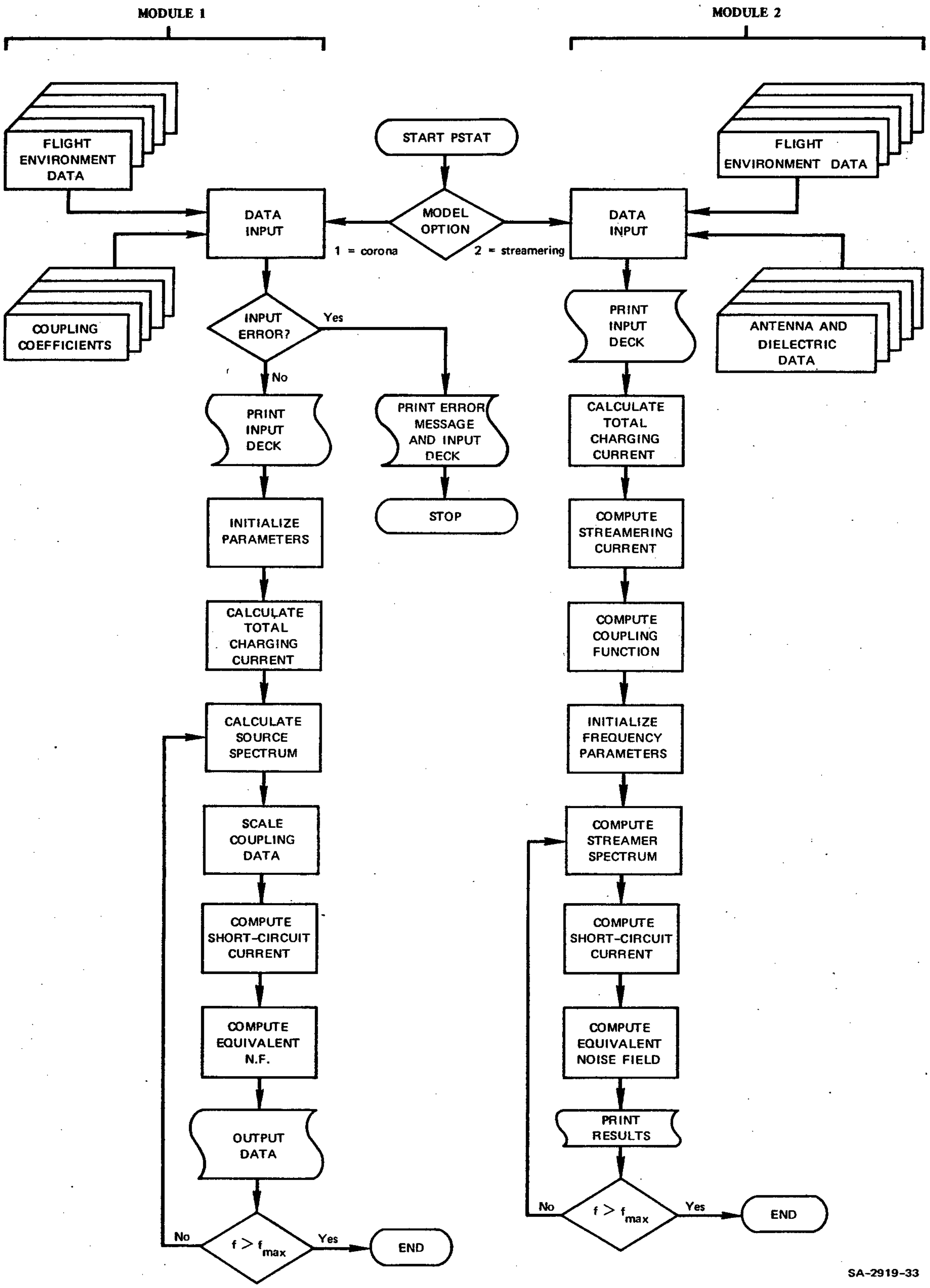

FIGURE 1 PSTAT FLOWCHART

input requirements of Module 2 were sufficiently simple that an input error check could not be justified, whereas the input requirements of Module 1, while not complex, were sufficiently confusing to warrant the error check.

A brief description of the contents of each program module is given below. The input and output details of each module are not discussed here, but are left for a later section of this manual. The mathematical processes of the calculations performed in the modules are fully described in the Final Report, so they will not be repeated here.

C. Module 1--Corona Noise

After the data cards have been input, an error check is made on several of the important parameters of the program. PSTAT will produce the error message

****DATA INPUT ERROR****

print the input deck, repeat the error message, and then halt, if any of the following errors are detected:

- More than 100 coupling coefficients for each extremity are either read into the program or requested to be read into the program.
- More than 90 frequencies have been read into the program or requested to be read into the program (for MODEF .NE.0). (Note: For MODEF .EQ.0 any number of frequencies may be evaluated--see description of constants and variables below.)
- The requested frequency ranges and/or frequency interval are not consistent--e.g., if the last frequency were smaller than the first frequency, or if Δf were 0 or negative--note: (This check is made only if MODEF .EQ.0).
- The discharge quench code does not reflect any of the possible quenching modes.
- The aircraft's altitude is greater than 80,000 ft.

After the input deck has passed the error check, it is printed out, showing the user the parameters he has selected for evaluation.

The next step in the program is the calculation of the total charging current to the aircraft. The total charging current (and hence discharging current in the steady-state case under consideration) is determined from the aircraft speed, its size (relative to a KC-135), and the type of cloud it is penetrating. At the same time the charging current is calculated, the probability that this charging current will be exceeded is also calculated.

Since the noise coupled into the antenna is a function of the antenna induction area and aircraft size, the coupling coefficients are then scaled to reflect the antenna induction area and the aircraft size. The next step in the program distributes the total charging current among the extremities (rudder, elevator tips, wing-tips) and then calculates the discharge source spectrum normalizers, which are used to determine the intensity of the corona spectra.

After the pressure (altitude) and frequency parameters have been initialized, the equivalent noise-field calculations begin. The spectral function, PREL, in the program is calculated using the approximations detailed in the Final Report, and the coupling data are linearly interpolated from the table of coupling coefficients established during the input phase of the program.

After the short-circuit antenna current and equivalent noise fields have been calculated they are printed out for the frequency currently being investigated. A frequency-increment test directs the program either to a "continue processing" statement or to a "completion" statement.

D. Module 2--Streamer Noise

The technique used to calculate the equivalent noise caused by streamer discharge closely parallels the technique used to calculate corona noise. After the data cards have been read in, the input deck is printed showing the user the parameters he has selected for evaluation. This serves as an error check on the input data.

The next step in the program is the calculation of the total charging current to the aircraft. The total charging current is determined from the aircraft speed, size, and type of cloud it is penetrating. At this same time, the probability that this charging current will be exceeded is also calculated.

The next step in the program is the calculation of the streamering current. The streamering current is given by the ratio of the dielectric surface frontal area to the total aircraft frontal area multiplied by the calculated aircraft charging current.

After the frequency parameters have been initialized, the streamer spectrum is calculated at the particular frequency being examined. The short circuit antenna current is then calculated and the equivalent noise field is finally obtained and printed out. A frequency increment-test directs the program either to a "continue" processing, or a "completion" statement.

The inherent qualities of program PSTAT are that, in the brief module descriptions given above, many years of accumulated experimental data have been combined to form a unified program to solve many types of problems involving precipitation-static-induced noise in avionics systems. While the program, taken in its entirety involves considerable sophistication, the individual calculations are quite simple and easily followed in the program documentation. Accordingly, we have not provided flow charts for the calculation of every parameter because it was felt that they would be simple but so numerous as to detract from the utility of this manual.

IV INPUT

PSTAT utilizes three input areas: (1) The initial one-card input to specify Module 1 (corona noise) or Module 2 (streamer noise), (2) the input area for the corona-noise calculation, and (3) the input area for the streamer-noise calculation.

At any one time the user will use only two of these areas: The module-select area and the corona-noise area, or the module-select area and the streamer-noise area.

The requirements and formats for each of these areas are given below. The order in which the material is presented is the order in which the input deck should be arranged.

A. Module Select Area

- Card 1--This will always be the first card of the data deck, and it contains either a 1 (Module 1), or a 2 (Module 2) and directs the program to the desired module. The card should be in an I1 format.

B. Corona-Noise Module

The description of each of the cards to be input into this module is given below, in the order of their location in the input deck.

- Card 2--LA, LANT; Format I1, 1X, 7A2

  LANT is a 14-character alphanumeric briefly describing the location of the antenna under test (i.e., BELLY, FUSELAGE, TAILCAP, etc.) and is used only for output annotation.

  LA is a single-digit fixed-point variable describing the antenna location. Set LA = 0 if the antenna is not located at, or near, an extremity (e.g., a belly-mounted antenna).

If the antenna is located at, or near, the elevator extremity, set LA = 1. If the antenna is located at, or near, a wing-tip, set LA = 2. Set LA = 3 if the antenna is located at, or near, the rudder extremity. This parameter is used to scale the coupling coefficients to the scale size of the aircraft, for those discharge locations not located near the antenna. The coupling coefficient describing the coupling between noise sources and extremity-located antennas is not scaled to aircraft scale size if the antenna is located near those noise sources. The other coupling coefficients, however, are scaled, and the reasons for scaling are described in the final report.

- Card 3--NCOUP; Format I3

  This is a fixed-point number specifying the number of coupling coefficients to be read from cards (Maximum = 100).

- Card 4--ESTO, WSTO, RSTO; Format 3(E9.2,1X)

  These are the array names for the storage of the NCOUP coupling coefficients. The data on these cards are experimentally derived quantities and until the user gains familiarity with the program, or until more data become available, the SRI-supplied decks of coupling coefficients should be used. The user should note that SRI has supplied two decks of coupling coefficients: one for extremity-to-tail-cap antennas; and one for extremity-to-belly antennas. The user should select the deck appropriate to his needs--tail-cap or belly-mounted (fuselage-mounted) antennas.

- Card 5--NRUN; Format I3

  This card specifies the number of program cycles to be made using the same coupling data but various other parameters. It is suggested that until the user is familiar with the program, NRUN be limited to 1.

- Card 6--IOFF; Format I1

  This card specifies which (if any) of the corona discharges should be suppressed by 40 dB. (40 dB is typical of the quieting provided by p-static dischargers on aircraft.) The codes are as follows:

IOFF = 1 All discharges permitted

IOFF = 2 Rudder discharge quieted by 40 dB

IOFF = 3 Wing-tip discharges quieted by 40 dB

IOFF = 4 Elevator-tip discharges quieted by 40 dB

IOFF = 5 Rudder and wing-tip discharges quieted by 40 dB

IOFF = 6 Rudder and elevator-tip discharges quieted by 40 dB

IOFF = 7 Elevator and wing-tip discharges quieted by 40 dB.

- Card 7--IT; Format 6A2

  This is a 12-character alphanumeric describing the type of aircraft under investigation (i.e., TRANSPORT, FIGHTER, etc.), and is used only for output annotation.

- Card 8--XN, SPD, ALT; Format F5.2, 1X, F6.1, 1X, F4.1

  This card contains the information about the aircraft's size, XN (relative to a KC-135), and its speed (in mph) and its operating altitude (in kft).

- Card 9--MODEF; Format I1

  This card specifies the frequency-select mode the user wishes to use. If MODEF equals 0, it means that the user has decided to use uniformly spaced frequency intervals. If MODEF is not equal to 0, it means that the user has decided to use frequencies that will be read in from cards at a nonuniform Δf.

- Card 10--(If MODEF .EQ.0) FSTRT, FSTP, FDEL; Format 3(F5.2, 1X)

  This card contains the desired starting frequency (in MHz), ending frequency (in MHz), and frequency increment (in MHz) if MODEF is equal to zero.

- Card 10--(If MODEF .NE.0) NFR; Format I3

  This card specifies the number of user-selected frequencies to be read into the program. (The maximum number allowed is 90.)

- Cards 10a, 10b, 10c, etc.--(If MODEF .NE.0) FREQU; Format E9.2

  These cards are the user-selected frequencies (in MHz). There should be NFR of these cards.

- Card 11--AANT, BNDW; Format 2(F5.2, 2X)

  This card contains the information specifying the receiving antenna's induction area (in m^2) and the receiver bandwidth (in kHz).

- Card 12--ICLO, IC; Format I1, 1X, 7A2

  This card contains the information about the type of particulate material the aircraft is flying in.

  ICLO = 1 implies a cirrus cloud or low charging material.

  ICLO = 2 implies a stratocumulus cloud or moderate charging material.

  ICLO = 4 implies a snow cloud or high-charging material.

  IC is a 14-character alphanumeric description of the cloud material. It is used only for output annotation.

C. Streamer-Noise Module

- Card 2--LANT; Format 4A2

  This alphanumeric is described in Section IV-B above.

- Card 3--IT; Format 6A2

  This alphanumeric is described in Section IV-B above.

- Card 4--XN, SPD, ALT; Format F5.2, 1X, F6.1, 1X, F4.1

  The data on this card are described in Section IV-B above.

- Card 5--MODEF; Format I1

  The data on this card are described in Section IV-B above.

- Card 6--(If MODEF .EQ.0) FSTRT, FSTP, FDEL; Format 3(F5.2, 1X)

  The data on this card are described in Section IV-B above.

- Card 6--(If MODEF .NE.0) NFR; Format I3

  The data on this card are described in Section IV-B above.

- Card 6a, 6b, 6c--(If MODEF .NE.0) FREQU; Format E9.2

  The data on these cards are described in Section IV-B above.

- Card 7--AANT, BNDW; Format 2(F5.2, 2X)

  The data on this card are described in Section IV-B above.

- Card 8--ICLO, IC; Format I1, 1X, 7A2

  The data on this card are described in Section IV-B above.

- Card 9--IM, IMAT; Format I1, 1X, 7A2

  This card contains the information about the type of dielectric material being charged.

  IM = 1 implies that a windshield (canopy) is being charged.

  IM = 2 implies that a radome is being charged.

  IMAT is a 14-character alphanumeric description of the dielectric material (i.e., WINDSHIELD, or RADOME). It is used only for output annotation.

- Card 10--DAFT,WX; Format 2(F5.2, 2X)

  This card describes the antenna location with respect to the charging material, and the minimum characteristic dimension of the dielectric material being charged.

  DAFT specifies the distance (in meters) the receiving antenna is located behind the windshield canopy or the radome. If the receiving antenna is located immediately beneath the dielectric material, DAFT should be read in as 0.00 m.

  WX specifies the minimum characteristic dimension (in meters) of the dielectric material being charged--i.e., the width of a rectangular section of dielectric. The floating-point variable, WX, may be thought of as roughly twice the length of the longest possible streamer discharge on the dielectric region under consideration.

- Card 11--DIERAT; Format F5.2

  DIERAT is the ratio of the frontal area of the dielectric to the frontal area of the aircraft.

  In the event that windshield canopy streamering is being considered, DIERAT should specify the ratio of the total frontal area of the dielectric to the total frontal area of the aircraft.

If radome streamering is being considered, DIERAT should specify the ratio of the radome's forward 3 feet of area to the total frontal area of the aircraft.

It can be seen from the input requirements described above that the use of alphanumerics has been limited to annotation only, while parameters which affect the processing has been limited to BCD (numbers). This technique could have been changed so that alphanumerics directed some of the processing, but it was felt that this would confuse the input requirements of PSTAT. The example INPUT/OUTPUT shown later in this volume will illustrate the use of the BCD/Alphanumerics input data described above.

V OUTPUT

During output, the user-supplied quantities that affect the computed results are printed out before the induced equivalent noise fields are printed out.

If an error is detected during the processing of the corona-noise input deck, an error message is produced. No error checks are made during the processing of the streamer-noise input deck, since the input requirements for this module are quite simple.

After the input quantities have been listed, the charging current is calculated and printed out. The probability that the charging current will exceed the calculated value (for the specified conditions of altitude, speed, aircraft size, and cloud type) is also calculated and printed out.

The short-circuit currents induced in the receiving antenna and the associated equivalent noise fields are then calculated and printed out for all of the user-desired frequencies. The dimensions of these output quantities are megahertz and hertz for the user-specified frequencies, amperes for the short-circuit current, and volts per meter for the equivalent noise fields.

It should be noted here that if the user elects to use the streamering model for an antenna immediately beneath the canopy or radome, no equivalent noise field is calculated or printed. The reasons for this are fully described in the final report.

Examples of the output are given in a later section of this manual.

VI SAMPLE INPUT/OUTPUT

This section gives several examples of the use of program PSTAT, together with example input deck setup and output listing.

A. Example 1

Calculate the equivalent noise field induced in an antenna on the tail-cap of a KC-135 transport aircraft. Assume that the antenna has an induction area of 8.6 m^2, and that the receiver has a bandwidth of 1 kHz. Further assume that the aircraft is flying at a speed of 600 mph at an altitude of 20,000 feet through cirrus cloud. Allow all extremities of the aircraft to discharge and evaluate the equivalent noise fields at uniformly spaced frequencies of from 0.1 MHz to 4.0 MHz in steps of 0.1 MHz.

1. <u>Input Deck</u>

The input deck required to evaluate this problem is as follows:

```
1
3=TAILCAP
 15,
+0.41E-03 +0.23E-03 +0.35E-01          0 MHZ TAILCAP
+0.35E-03 +0.30E-03 +0.35E-01          1 MHZ TAILCAP
+0.20E-03 +0.56E-03 +0.35E-01          2 MHZ TAILCAP
+0.30E-02 +0.16E-02 +0.35E-01          3 MHZ TAILCAP
+0.50E-02 +0.21E-02 +0.35E-01          4 MHZ TAILCAP
+0.27E-02 +0.11E-02 +0.37E-01          5 MHZ TAILCAP
+0.27E-02 +0.75E-02 +0.40E-01          6 MHZ TAILCAP
+0.32E-02 +0.10E-02 +0.39E-01          7 MHZ TAILCAP
+0.43E-02 +0.17E-02 +0.38E-01          8 MHZ TAILCAP
+0.70E-02 +0.10E-02 +0.35E-01          9 MHZ TAILCAP
+0.10E-01 +0.40E-03 +0.35E-01          10MHZ TAILCAP
+0.13E-01 +0.42E-03 +0.40E-01          11MHZ TAILCAP
+0.13E-01 +0.74E-03 +0.51E-01          12MHZ TAILCAP
+0.12E-01 +0.90E-03 +0.57E-01          13MHZ TAILCAP
+0.10E-01 +0.10E-02 +0.55E-02          14MHZ TAILCAP
1,
1
KC-135
 1.00  600.0 80.0
0
 0.10  4.00  0.10
 8.6 ,  1.0
1=CIRRUS CLOUD
```

2. Output Deck

The program output is as follows:

```
                    SRI STATIC ELECTRICITY MODEL

P-STATIC MODEL EVALUATED FOR A KC-135        AIRCRAFT
WITH THE RECEIVING ANTENNA LOCATED AT THE TAILCAP

SCALE SIZE          SPEED          ALTITUDE          CLOUD TYPE
                    [MPH]          [KFT]

  1.00              600.0            20.0            CIRRUS CLOUD

START FREQ.     STOP FREQ.     DELTA-F
  [MHZ]           [MHZ]          [MHZ]

   .10            4.00           .10

RECEIVER            ANTENNA
NOISE               INDUCTION
BANDWIDTH           AREA
 [KHZ]              [M**2]

 1.00                8.60

ALL DISCHARGES PERMITTED
```

THE CALCULATED CHARGING CURRENT IS 1.000E-03 AMPS

THE PROBABILITY IS .0020 THAT THE CHARGING CURRENT
WILL BE GREATER THAN 1.000E-03 AMPS

FREQUENCY [MHZ]	FREQUENCY [HZ]	SHORT-CIRCUIT CURRENT [AMPS]	EQUIVALENT NOISE FIELD [VOLTS/M]	EQUIVALENT NOISE FIELD [DBV/M]
.10	1.000E 05	8.434E-07	1.765E-02	-3.506E 01
.20	2.000E 05	8.376E-07	8.765E-03	-4.114E 01
.30	3.000E 05	8.281E-07	5.777E-03	-4.476E 01
.40	4.000E 05	8.154E-07	4.267E-03	-4.739E 01
.50	5.000E 05	7.999E-07	3.348E-03	-4.949E 01
.60	6.000E 05	7.821E-07	2.728E-03	-5.127E 01
.70	7.000E 05	7.625E-07	2.280E-03	-5.283E 01
.80	8.000E 05	7.416E-07	1.940E-03	-5.423E 01
.90	9.000E 05	7.199E-07	1.674E-03	-5.551E 01
1.00	1.000E 06	6.978E-07	1.460E-03	-5.670E 01
1.10	1.100E 06	6.755E-07	1.285E-03	-5.781E 01
1.20	1.200E 06	6.535E-07	1.140E-03	-5.885E 01
1.30	1.300E 06	6.318E-07	1.017E-03	-5.984E 01
1.40	1.400E 06	6.106E-07	9.129E-04	-6.078E 01
1.50	1.500E 06	5.901E-07	8.234E-04	-6.168E 01
1.60	1.600E 06	5.703E-07	7.461E-04	-6.253E 01
1.70	1.700E 06	5.513E-07	6.788E-04	-6.335E 01
1.80	1.800E 06	5.331E-07	6.198E-04	-6.414E 01
1.90	1.900E 06	5.156E-07	5.680E-04	-6.490E 01
2.00	2.000E 06	4.990E-07	5.222E-04	-6.563E 01
2.10	2.100E 06	4.833E-07	4.817E-04	-6.633E 01
2.20	2.200E 06	4.683E-07	4.456E-04	-6.701E 01
2.30	2.300E 06	4.542E-07	4.133E-04	-6.766E 01
2.40	2.400E 06	4.408E-07	3.844E-04	-6.829E 01
2.50	2.500E 06	4.281E-07	3.584E-04	-6.890E 01
2.60	2.600E 06	4.161E-07	3.349E-04	-6.949E 01
2.70	2.700E 06	4.047E-07	3.137E-04	-7.006E 01
2.80	2.800E 06	3.939E-07	2.944E-04	-7.061E 01
2.90	2.900E 06	3.837E-07	2.769E-04	-7.114E 01
3.00	3.000E 06	3.740E-07	2.609E-04	-7.166E 01
3.10	3.100E 06	3.645E-07	2.461E-04	-7.216E 01
3.20	3.200E 06	3.556E-07	2.326E-04	-7.266E 01
3.30	3.300E 06	3.470E-07	2.201E-04	-7.313E 01
3.40	3.400E 06	3.389E-07	2.086E-04	-7.360E 01
3.50	3.500E 06	3.312E-07	1.980E-04	-7.405E 01
3.60	3.600E 06	3.237E-07	1.882E-04	-7.449E 01
3.70	3.700E 06	3.167E-07	1.791E-04	-7.492E 01
3.80	3.800E 06	3.099E-07	1.707E-04	-7.534E 01
3.90	3.900E 06	3.035E-07	1.629E-04	-7.575E 01
4.00	4.000E 06	2.973E-07	1.556E-04	-7.615E 01

B. Example 2

Repeat the above example, but quiet the rudder discharge. (This might be done to investigate the effects of adding p-static dischargers to the rudder assembly of the aircraft.)

1. Input Deck

The input deck required to evaluate this problem is as follows:

```
1
3=TAILCAP
 15,
+0.41E-03 +0.23E-03 +0.35E-01               0 MHZ TAILCAP
+0.35E-03 +0.30E-03 +0.35E-01               1 MHZ TAILCAP
+0.20E-03 +0.56E-03 +0.35E-01               2 MHZ TAILCAP
+0.30E-02 +0.16E-02 +0.35E-01               3 MHZ TAILCAP
+0.50E-02 +0.21E-02 +0.35E-01               4 MHZ TAILCAP
+0.27E-02 +0.11E-02 +0.37E-01               5 MHZ TAILCAP
+0.27E-02 +0.75E-02 +0.40E-01               6 MHZ TAILCAP
+0.32E-02 +0.10E-02 +0.39E-01               7 MHZ TAILCAP
+0.43E-02 +0.17E-02 +0.38E-01               8 MHZ TAILCAP
+0.70E-02 +0.10E-02 +0.35E-01               9 MHZ TAILCAP
+0.10E-01 +0.40E-03 +0.35E-01               10MHZ TAILCAP
+0.13E-01 +0.42E-03 +0.40E-01               11MHZ TAILCAP
+0.13E-01 +0.74E-03 +0.51E-01               12MHZ TAILCAP
+0.12E-01 +0.90E-03 +0.57E-01               13MHZ TAILCAP
+0.10E-01 +0.10E-02 +0.55E-02               14MHZ TAILCAP
1,
2
KC-135
 1.00  600.0 30.0
0
 0.10  4.00  0.10
 8.6 ,  1.0
1=CIRRUS CLOUD
```

2. <u>Output Deck</u>

The program output is as follows:

```
                    SRI STATIC ELECTRICITY MODEL

 P-STATIC MODEL EVALUATED FOR A KC-135        AIRCRAFT
 WITH THE RECEIVING ANTENNA LOCATED AT THE TAILCAP

 SCALE SIZE          SPEED         ALTITUDE         CLOUD TYPE
                     [MPH]          [KFT]

    1.00             600.0           20.0           CIRRUS CLOUD

 START FREQ.      STOP FREQ.     DELTA-F
   [MHZ]            [MHZ]         [MHZ]

    .10              4.00          .10

 RECEIVER            ANTENNA
 NOISE               INDUCTION
 BANDWIDTH           AREA
  [KHZ]              [M**2]

   1.00               2.60

 RUDDER DISCHARGE PROHIBITED
```

SRI P-STATIC MODEL [CONTD]

THE CALCULATED CHARGING CURRENT IS 1.000E-03 AMPS

THE PROBABILITY IS .0020 THAT THE CHARGING CURRENT
WILL BE GREATER THAN 1.000E-03 AMPS

FREQUENCY [MHZ]	FREQUENCY [HZ]	SHORT-CIRCUIT CURRENT [AMPS]	EQUIVALENT NOISE FIELD [VOLTS/M]	EQUIVALENT NOISE FIELD [DBV/M]
.10	1.000E 05	1.849E-08	3.870E-04	-6.823E 01
.20	2.000E 05	1.834E-08	1.920E-04	-7.432E 01
.30	3.000E 05	1.812E-08	1.264E-04	-7.795E 01
.40	4.000E 05	1.784E-08	9.334E-05	-8.058E 01
.50	5.000E 05	1.750E-08	7.325E-05	-8.269E 01
.60	6.000E 05	1.711E-08	5.970E-05	-8.447E 01
.70	7.000E 05	1.670E-08	4.992E-05	-8.602E 01
.80	8.000E 05	1.625E-08	4.252E-05	-8.741E 01
.90	9.000E 05	1.580E-08	3.674E-05	-8.868E 01
1.00	1.000E 06	1.534E-08	3.210E-05	-8.985E 01
1.10	1.100E 06	1.510E-08	2.873E-05	-9.082E 01
1.20	1.200E 06	1.489E-08	2.597E-05	-9.169E 01
1.30	1.300E 06	1.472E-08	2.369E-05	-9.249E 01
1.40	1.400E 06	1.457E-08	2.178E-05	-9.322E 01
1.50	1.500E 06	1.445E-08	2.016E-05	-9.389E 01
1.60	1.600E 06	1.435E-08	1.878E-05	-9.451E 01
1.70	1.700E 06	1.428E-08	1.758E-05	-9.508E 01
1.80	1.800E 06	1.422E-08	1.653E-05	-9.562E 01
1.90	1.900E 06	1.417E-08	1.561E-05	-9.611E 01
2.00	2.000E 06	1.414E-08	1.480E-05	-9.658E 01
2.10	2.100E 06	1.790E-08	1.784E-05	-9.495E 01
2.20	2.200E 06	2.216E-08	2.108E-05	-9.350E 01
2.30	2.300E 06	2.650E-08	2.411E-05	-9.234E 01
2.40	2.400E 06	3.073E-08	2.680E-05	-9.142E 01
2.50	2.500E 06	3.481E-08	2.914E-05	-9.069E 01
2.60	2.600E 06	3.870E-08	3.115E-05	-9.011E 01
2.70	2.700E 06	4.240E-08	3.286E-05	-8.965E 01
2.80	2.800E 06	4.590E-08	3.431E-05	-8.927E 01
2.90	2.900E 06	4.923E-08	3.553E-05	-8.897E 01
3.00	3.000E 06	5.238E-08	3.654E-05	-8.873E 01
3.10	3.100E 06	5.392E-08	3.640E-05	-8.876E 01
3.20	3.200E 06	5.538E-08	3.622E-05	-8.880E 01
3.30	3.300E 06	5.677E-08	3.601E-05	-8.886E 01
3.40	3.400E 06	5.810E-08	3.576E-05	-8.891E 01
3.50	3.500E 06	5.936E-08	3.550E-05	-8.898E 01
3.60	3.600E 06	6.056E-08	3.521E-05	-8.905E 01
3.70	3.700E 06	6.170E-08	3.490E-05	-8.913E 01
3.80	3.800E 06	6.279E-08	3.458E-05	-8.921E 01
3.90	3.900E 06	6.383E-08	3.425E-05	-8.929E 01
4.00	4.000E 06	6.482E-08	3.392E-05	-8.938E 01

C. <u>Example 3</u>

Calculate the equivalent noise field induced in a belly-mounted antenna on an F-4 aircraft. Assume that the antenna has an induction area of 8.6 m^2, and that the receiver has a bandwidth of 1 kHz. Further assume that the aircraft is flying at a speed of 600 mph at 20 kft through stratocumulus cloud. Allow all extremities of the aircraft to discharge and evaluate the ENF at uniformly spaced frequencies of 0.1 to 4.0 MHz with a Δf of 0.1 MHz. (The F-4 is approximately 1/3 the size of a KC-135.)

1. <u>Input Deck</u>

The input deck required to evaluate this problem is as follows:

```
1
0=BELLY
 15,
+0.14E-03 +0.20E-03 +0.90E-05          0 MHZ BELLY
+0.15E-03 +0.22E-03 +0.11E-03          1 MHZ BELLY
+0.20E-03 +0.27E-03 +0.18E-03          2 MHZ BELLY
+0.16E-02 +0.55E-03 +0.85E-03          3 MHZ BELLY
+0.10E-02 +0.17E-02 +0.40E-03          4 MHZ BELLY
+0.30E-03 +0.80E-03 +0.12E-03          5 MHZ BELLY
+0.50E-03 +0.55E-03 +0.23E-03          6 MHZ BELLY
+0.85E-03 +0.11E-02 +0.40E-03          7 MHZ BELLY
+0.17E-02 +0.27E-02 +0.10E-02          8MHZ BELLY
+0.24E-02 +0.29E-02 +0.15E-02          9 MHZ BELLY
+0.22E-02 +0.29E-02 +0.16E-02          10 MHZ BELLY
+0.15E-02 +0.42E-02 +0.10E-02          11 MHZ BELLY
+0.18E-02 +0.65E-02 +0.70E-03          12 MHZ BELLY
+0.19E-02 +0.50E-02 +0.62E-03          13 MHZ BELLY
+0.20E-02 +0.46E-02 +0.60E-03          14 MHZ BELLY
1,
1
F-4 FIGHTER
 0.33  600.0 20.0
0
 0.10  4.00  0.10
 8.6 ,  1.0
2=STRAT9 CU
```

2. Output Deck

The program output is as follows:

SRI STATIC ELECTRICITY MØDEL

P-STATIC MØDEL EVALUATED FØR A F-4 FIGHTER AIRCRAFT
WITH THE RECEIVING ANTENNA LØCATED AT THE BELLY

SCALE SIZE	SPEED [MPH]	ALTITUDE [KFT]	CLØUD TYPE
.33	600.0	20.0	STRATØ CU

START FREQ. [MHZ]	STØP FREQ. [MHZ]	DELTA-F [MHZ]
.10	4.00	.10

RECEIVER NØISE BANDWIDTH [KHZ]	ANTENNA INDUCTIØN AREA [M**2]
1.00	8.60

ALL DISCHARGES PERMITTED

SRI P-STATIC MODEL [CONTD]

THE CALCULATED CHARGING CURRENT IS 6.600E-04 AMPS

THE PROBABILITY IS .0061 THAT THE CHARGING CURRENT
WILL BE GREATER THAN 6.600E-04 AMPS

FREQUENCY [MHZ]	FREQUENCY [HZ]	SHORT-CIRCUIT CURRENT [AMPS]	EQUIVALENT NOISE FIELD [VOLTS/M]	EQUIVALENT NOISE FIELD [DBV/M]
.10	1.000E 05	1.171E-07	2.450E-03	-5.221E 01
.20	2.000E 05	1.166E-07	1.221E-03	-5.826E 01
.30	3.000E 05	1.157E-07	8.073E-04	-6.185E 01
.40	4.000E 05	1.143E-07	5.983E-04	-6.445E 01
.50	5.000E 05	1.126E-07	4.712E-04	-6.652E 01
.60	6.000E 05	1.104E-07	3.853E-04	-6.827E 01
.70	7.000E 05	1.081E-07	3.232E-04	-6.980E 01
.80	8.000E 05	1.055E-07	2.760E-04	-7.117E 01
.90	9.000E 05	1.028E-07	2.391E-04	-7.242E 01
1.00	1.000E 06	1.000E-07	2.094E-04	-7.357E 01
1.10	1.100E 06	9.722E-08	1.850E-04	-7.464E 01
1.20	1.200E 06	9.441E-08	1.647E-04	-7.565E 01
1.30	1.300E 06	9.164E-08	1.475E-04	-7.661E 01
1.40	1.400E 06	8.893E-08	1.330E-04	-7.751E 01
1.50	1.500E 06	8.629E-08	1.204E-04	-7.837E 01
1.60	1.600E 06	8.374E-08	1.095E-04	-7.919E 01
1.70	1.700E 06	8.129E-08	1.001E-04	-7.998E 01
1.80	1.800E 06	7.893E-08	9.178E-05	-8.073E 01
1.90	1.900E 06	7.667E-08	8.446E-05	-8.145E 01
2.00	2.000E 06	7.452E-08	7.798E-05	-8.215E 01
2.10	2.100E 06	7.246E-08	7.222E-05	-8.281E 01
2.20	2.200E 06	7.050E-08	6.707E-05	-8.345E 01
2.30	2.300E 06	6.863E-08	6.246E-05	-8.407E 01
2.40	2.400E 06	6.685E-08	5.830E-05	-8.467E 01
2.50	2.500E 06	6.516E-08	5.456E-05	-8.525E 01
2.60	2.600E 06	6.356E-08	5.116E-05	-8.581E 01
2.70	2.700E 06	6.202E-08	4.808E-05	-8.634E 01
2.80	2.800E 06	6.057E-08	4.527E-05	-8.687E 01
2.90	2.900E 06	5.918E-08	4.271E-05	-8.737E 01
3.00	3.000E 06	5.786E-08	4.037E-05	-8.786E 01
3.10	3.100E 06	5.678E-08	3.834E-05	-8.831E 01
3.20	3.200E 06	5.583E-08	3.652E-05	-8.873E 01
3.30	3.300E 06	5.492E-08	3.483E-05	-8.914E 01
3.40	3.400E 06	5.405E-08	3.327E-05	-8.954E 01
3.50	3.500E 06	5.321E-08	3.182E-05	-8.993E 01
3.60	3.600E 06	5.241E-08	3.047E-05	-9.031E 01
3.70	3.700E 06	5.164E-08	2.921E-05	-9.067E 01
3.80	3.800E 06	5.091E-08	2.804E-05	-9.103E 01
3.90	3.900E 06	5.020E-08	2.694E-05	-9.137E 01
4.00	4.000E 06	4.952E-08	2.591E-05	-9.171E 01

D. Example 4

Repeat Example 3, except assume that the aircraft is now flying through cirrus cloud.

1. Input Deck

The input deck required to evaluate this problem is as follows:

```
1
0=BELLY
 15,
+0.14E-03 +0.20E-03 +0.90E-05          0 MHZ BELLY
+0.15E-03 +0.22E-03 +0.11E-03          1 MHZ BELLY
+0.20E-03 +0.27E-03 +0.18E-03          2 MHZ BELLY
+0.16E-02 +0.55E-03 +0.35E-03          3 MHZ BELLY
+0.10E-02 +0.17E-02 +0.40E-03          4 MHZ BELLY
+0.30E-03 +0.80E-03 +0.12E-03          5 MHZ BELLY
+0.50E-03 +0.55E-03 +0.23E-03          6 MHZ BELLY
+0.85E-03 +0.11E-02 +0.40E-03          7 MHZ BELLY
+0.17E-02 +0.27E-02 +0.10E-02          8MHZ BELLY
+0.24E-02 +0.29E-02 +0.15E-02          9 MHZ BELLY
+0.22E-02 +0.29E-02 +0.16E-02          10 MHZ BELLY
+0.15E-02 +0.42E-02 +0.10E-02          11 MHZ BELLY
+0.18E-02 +0.65E-02 +0.70E-03          12 MHZ BELLY
+0.19E-02 +0.50E-02 +0.62E-03          13 MHZ BELLY
+0.20E-02 +0.46E-02 +0.60E-03          14 MHZ BELLY
1,
1
F-4 FIGHTER
 0.33  600.0 20.0
0
 0.10  4.00  0.10
 8.6 ,  1.0
1=CIRRUS CLOUD
```

2. Output Deck

The program output is as follows:

```
                 SRI STATIC ELECTRICITY MØDEL
------------------------------------------------------------------

P-STATIC MØDEL EVALUATED FØR A F-4 FIGHTER  AIRCRAFT
WITH THE RECEIVING ANTENNA LØCATED AT THE BELLY
------------------------------------------------------------------
SCALE SIZE          SPEED        ALTITUDE        CLØUD TYPE
                    [MPH]         [KFT]

     .33            600.0         20.0           CIRRUS CLØUD
------------------------------------------------------------------
START FREQ.     STØP FREQ.     DELTA-F
  [MHZ]           [MHZ]         [MHZ]

   .10             4.00          .10
------------------------------------------------------------------
RECEIVER          ANTENNA
NØISE             INDUCTIØN
BANDWIDTH          AREA
 [KHZ]             [M**2]
------------------------------------------------------------------
  1.00              8.60

ALL DISCHARGES PERMITTED
------------------------------------------------------------------
```

THE CALCULATED CHARGING CURRENT IS 3.300E-04 AMPS

THE PROBABILITY IS .0061 THAT THE CHARGING CURRENT
WILL BE GREATER THAN 3.300E-04 AMPS

FREQUENCY [MHZ]	FREQUENCY [HZ]	SHORT-CIRCUIT CURRENT [AMPS]	EQUIVALENT NOISE FIELD [VOLTS/M]	EQUIVALENT NOISE FIELD [DBV/M]
.10	1.000E 05	8.277E-08	1.732E-03	-5.522E 01
.20	2.000E 05	8.247E-08	8.631E-04	-6.127E 01
.30	3.000E 05	8.182E-08	5.709E-04	-6.486E 01
.40	4.000E 05	8.085E-08	4.230E-04	-6.746E 01
.50	5.000E 05	7.959E-08	3.332E-04	-6.953E 01
.60	6.000E 05	7.810E-08	2.724E-04	-7.128E 01
.70	7.000E 05	7.642E-08	2.285E-04	-7.281E 01
.80	8.000E 05	7.461E-08	1.952E-04	-7.418E 01
.90	9.000E 05	7.270E-08	1.691E-04	-7.543E 01
1.00	1.000E 06	7.073E-08	1.480E-04	-7.658E 01
1.10	1.100E 06	6.874E-08	1.308E-04	-7.765E 01
1.20	1.200E 06	6.676E-08	1.164E-04	-7.866E 01
1.30	1.300E 06	6.480E-08	1.043E-04	-7.962E 01
1.40	1.400E 06	6.288E-08	9.401E-05	-8.052E 01
1.50	1.500E 06	6.102E-08	8.514E-05	-8.138E 01
1.60	1.600E 06	5.921E-08	7.746E-05	-8.220E 01
1.70	1.700E 06	5.748E-08	7.077E-05	-8.299E 01
1.80	1.800E 06	5.581E-08	6.490E-05	-8.374E 01
1.90	1.900E 06	5.422E-08	5.972E-05	-8.446E 01
2.00	2.000E 06	5.269E-08	5.514E-05	-8.516E 01
2.10	2.100E 06	5.124E-08	5.107E-05	-8.582E 01
2.20	2.200E 06	4.985E-08	4.743E-05	-8.646E 01
2.30	2.300E 06	4.853E-08	4.416E-05	-8.708E 01
2.40	2.400E 06	4.727E-08	4.123E-05	-8.768E 01
2.50	2.500E 06	4.608E-08	3.858E-05	-8.826E 01
2.60	2.600E 06	4.494E-08	3.618E-05	-8.882E 01
2.70	2.700E 06	4.386E-08	3.400E-05	-8.935E 01
2.80	2.800E 06	4.283E-08	3.201E-05	-8.988E 01
2.90	2.900E 06	4.185E-08	3.020E-05	-9.038E 01
3.00	3.000E 06	4.091E-08	2.854E-05	-9.087E 01
3.10	3.100E 06	4.015E-08	2.711E-05	-9.132E 01
3.20	3.200E 06	3.948E-08	2.582E-05	-9.174E 01
3.30	3.300E 06	3.883E-08	2.463E-05	-9.215E 01
3.40	3.400E 06	3.822E-08	2.353E-05	-9.255E 01
3.50	3.500E 06	3.763E-08	2.250E-05	-9.294E 01
3.60	3.600E 06	3.706E-08	2.155E-05	-9.332E 01
3.70	3.700E 06	3.652E-08	2.066E-05	-9.368E 01
3.80	3.800E 06	3.600E-08	1.983E-05	-9.404E 01
3.90	3.900E 06	3.550E-08	1.905E-05	-9.438E 01
4.00	4.000E 06	3.502E-08	1.832E-05	-9.472E 01

E. Example 5

Using the streamering model, evaluate the ENF induced in an antenna mounted near the radome of a B-47 bomber due to cirrus-cloud-caused p-static charging. Assume that the antenna is 0.04 m aft of the front of the radome, and that the antenna has an induction area of 0.01 m^2. Assume that the minimum characteristic dimension of the radome is 0.24 m and that the ratio of the dielectric frontal area to the total aircraft frontal area is 0.01. Further assume that the size of the B-47 is 0.89 times the size of a KC-135, and that the B-47 is flying at 600 mph at 20,000 feet through cirrus cloud.

Evaluate the ENF at nonuniformly spaced frequencies of 1.13, 2.16, 4.35, 8.62, and 10.7 MHz for a receiver noise bandwidth of 1.0 kHz.

1. Input Deck

The input deck required to evaluate this problem is as follows:

```
2
NR RADOME
B-47 BOMBER
 0.89  600.0 20.0
1
  5
+1.13E+00
+2.16E+00
+4.35E+00
+8.62E+00
+1.07E+01
 0.10   1.00
1=CIRRUS
2=RADOME
 0.04  0.24  0.30
 0.01
```

2. Output Deck

The program output is as follows:

```
                    SRI STATIC ELECTRICITY MODEL

P-STATIC MODEL EVALUATED FOR A B-47 BOMBER  AIRCRAFT
WITH THE RECEIVING ANTENNA LOCATED AT THE NR RADOM

 FOR STREAMERING OCCURING ON THE RADOME
AND THE ANTENNA   .04 METERS AFT OF THE FRONT OF THE RADOME
AND A MINIMUM CHARACTERISTIC DIMENSION OF   .24 METERS OF THE DIELECTRIC RADOME
AND A FUSELAGE DIAMETER OF   .30 METERS
 AND A DIELECTRIC AREA TO A/C FRONTAL AREA RATIO OF   .01

SCALE SIZE         SPEED        ALTITUDE        CLOUD TYPE
                   [MPH]         [KFT]

   .89             600.0         20.0           CIRRUS

START FREQ.    STOP FREQ.     DELTA-F
  [MHZ]          [MHZ]         [MHZ]

  1.13           10.70      NON-UNIFORM

RECEIVER         ANTENNA
NOISE            INDUCTION
BANDWIDTH         AREA
 [KHZ]           [M**2]

 1.00             .10
```

SRI P-STATIC MODEL [CONTD]

THE CALCULATED CHARGING CURRENT IS 8.900E-04 AMPS

THE PROBABILITY IS .0022 THAT THE CHARGING CURRENT
WILL BE GREATER THAN 8.900E-04 AMPS

THE CALCULATED STREAMERING CURRENT IS 8.90E-06 AMPS

FREQUENCY [MHZ]	FREQUENCY [HZ]	SHORT-CIRCUIT CURRENT [AMPS]	EQUIVALENT NOISE FIELD [VOLTS/M]	EQUIVALENT NOISE FIELD [DBV/M]
1.13	1.130E 06	6.299E-10	1.003E-04	-7.996E 01
2.16	2.160E 06	2.292E-10	1.910E-05	-9.436E 01
4.35	4.350E 06	6.883E-11	2.848E-06	-1.109E 02
8.62	8.620E 06	1.913E-11	3.995E-07	-1.279E 02
10.70	1.070E 07	1.260E-11	2.119E-07	-1.335E 02

Appendix

PSTAT PROGRAM LISTING

```
C
C
C  *PSTAT*   OCT 1974 VERSION  D**2  SRI, MENLO PARK, CAL.
C
C
C
C    PSTAT COMPUTES THE EQUIVALENT NOISE FIELDS GENERATED IN AN
C   AIRCRAFT ANTENNA DUE TO ELECTROSTATIC DISCHARGES OCCURING FROM THE
C   AIRFOIL EXTREMITIES. OR...
C    PSTAT COMPUTES THE EQUIVALENT NOISE FIELDS INDUCED IN AN AIRCRAFT
C   ANTENNA DUE TO STREAMERING DISCHARGES ON DIELECTRIC CANOPY OR
C   RADOME SURFACES.
C    THE USER CAN SELECT EITHER MODE OF PROGRAM EXECUTION BY AN
C   APPROPIATE DATA CARD.
C
C    PRESENT (1974) COUPLING DATA (DATA DESCRIBING THE ELECTROMAGNETIC
C   COUPLING BETWEEN AN AIRFOIL TIP AND AN ANTENNA) ONLY EXISTS FOR
C   BELLY- AND TAILCAP-MOUNTED ANTENNAS AND DISCHARGE LOCATIONS AT THE
C   WING, RUDDER, AND ELEVATOR TIPS. (OTHER POSSIBLE DISCHARGE LOCATIONS
C   ARE UNIMPORTANT FOR REASONS DESCRIBED IN THE FINAL REPORT).
C
C    THE PROGRAM IS GENERALIZED, SO THAT AS ADDITIONAL COUPLING DATA
C   BECOMES AVAILABLE, IT MAY BE INCORPORATED INTO THE PROGRAM.  THE
C   ADDITIONAL DATA MAY BE AN EXTENSION OF THE FREQUENCY RANGE OF THE
C   EXISTING DATA (IN 1-MHZ INTERVALS, UP TO 100-MHZ), OR COUPLING
C   DATA (AGAIN, IN 1-MHZ INTERVALS, UP TO 100-MHZ) FOR ANTENNAS
C   LOCATED IN OTHER POSITIONS.  THE COUPLING DATA USED IN PSTAT IS
C   EXPERIMENTAL DATA OBTAINED FROM KC-135 SCALE MODEL AND FLIGHT TESTS,
C   AND IS READ INTO THE PROGRAM FROM CARDS.
C
C    SRI HAS SUPPLIED TWO DECKS OF COUPLING DATA, EACH DECK CONSISTING
C   OF 15 CARDS (0 TO 14MHZ IN 1MHZ INTERVALS).  ONE DECK IS FOR
C   EXTREMITY-TO-TAILCAP COUPLING, AND THE OTHER IS FOR EXTREMITY-TO-
C   BELLY (FUSELAGE) COUPLING.  THE USER SHOULD SELECT THE DECK
C   APPROPIATE TO HIS NEEDS.
C
C    SINCE THE SPECTRUM OF CORONA DISCHARGE NOISE FALLS OFF AS 1/F,
C   A 100-MHZ FREQUENCY RANGE IS ADEQUATE TO HANDLE MOST CASES OF INTER-
C   EST, AND PSTAT PRESENTLY LIMITS THE CALCULATION TO FREQUENCIES AT OR
C   BELOW 100-MHZ.  SHOULD A HIGHER FREQUENCY RANGE BE DESIRED,A SIMPLE
C   PROGRAM MODIFICATION MAY BE MADE TO DO SO, AFTER CONSULTING THE
C   USERS GUIDE FOR DIRECTIONS.
C    DUE TO THE NATURE OF STREAMERING, AND THE INPUT REQUIREMENTS FOR
C   CALCULATING EQUIVALENT NOISE FIELDS, SEPARATE SECTIONS OF THIS
C   PROGRAM ARE DEVOTED TO THE CALCULATION OF STREAMER NOISE OR CORONA
C   NOISE.  THE DESIRED SECTION IS SELECTED BY THE USER AS THE FIRST
C   DATA CARD READ INTO THE PROGRAM.  A 1 (ONE) ON INPUT IMPLIES
C   SECTION ONE, THE CORONA SECTION.  A 2 (TWO) ON INPUT IMPLIES SECTION
C   2, THE STREAMERING SECTION.
C
C
C         *****CONSTANTS DEFINITION*****
C     LA=ANTENNA LOCATION ON EXTREMITY
C         IF LA=0, PGM ASSUMES THAT ANTENNA IS NOT LOCATED ON EXTREMITY
```

```
C         IF LA=1, ANTENNA IS ON (OR NEAR) ELEVATOR TIP                      PSTAT055
C         IF LA=2, ANTENNA IS ON (OR NEAR) WING TIP                          PSTAT056
C         IF LA=3, ANTENNA IS ON (OR NEAR) WING TIP                          PSTAT057
C     LANT=14 CHARACTER ALPHANUMERIC DESCRIPTION OF ANTENNA LOCATION         PSTAT058
C     IERR= ERROR FLAG-- SET=1 IF DATA INPUT ERROR OCCURS                    PSTAT059
C     EPSIL= EPSILON-- PERMITTIVITY OF FREE SPACE (FARADS/METER)             PSTAT060
C     NCOUP= NUMBER OF COUPLING COEFFICIENTS TO BE READ (NCOUP ALSO          PSTAT061
C           DEFINES THE MAXIMUM FREQUENCY + 1MHZ)                            PSTAT062
C     ESTO,WSTO,RSTO= STORAGE ARRAYS FOR NCOUP COUPLING COEFFICIENTS         PSTAT063
C                     FROM ELEVATORS, WINGS, RUDDER TO SELECTED ANTENNA      PSTAT064
C                     LOCATION                                               PSTAT065
C     NCO= NCOUP + 1                                                         PSTAT066
C     NRUN= NUMBER OF PROGRAM CYCLES TO BE MADE USING THE SAME COUPLING      PSTAT067
C           DATA, BUT (POSSIBLY) VARIOUS OTHER PARAMETERS                    PSTAT068
C     IOFF=CORONA DISCHARGE QUENCH CODE (AIRFOIL(S) P-STATIC PROTECTED)      PSTAT069
C         = 1--ALL DISCHARGES PERMITTED                                      PSTAT070
C         = 2--RUDDER DISCHARGE QUIETED BY 40 DB                             PSTAT071
C         = 3--WING TIPS DISCHARGE QUIETED BY 40 DB                          PSTAT072
C         = 4--ELEVATOR TIPS DISCHARGE QUIETED BY 40 DB                      PSTAT073
C         = 5--RUDDER AND WING TIPS DISCHARGES QUIETED BY 40 DB              PSTAT074
C         = 6--RUDDER AND ELEVATOR TIPS DISCHARGES QUIETED BY 40 DB          PSTAT075
C         = 7--ELEVATOR AND WING TIPS DISCHARGES QUIETED BY 40 DB            PSTAT076
C     IT= 6 WORD ALPHANUMERIC DESCRIPTION OF AIRCRAFT                        PSTAT077
C     XN= AIRCRAFT SCALE SIZE (RELATIVE TO A KC-135)                         PSTAT078
C     SPD= AIRCRAFT SPEED (IN MILES/HOUR)                                    PSTAT079
C     ALT= AIRCRAFT ALTITUDE (IN KILOFEET)                                   PSTAT080
C     MODEF= FREQUENCY SELECT MODE (.EQ. / MEANS UNIFORM FREQUENCY           PSTAT081
C           INTERVALS,  .NE. 0 MEANS USER SELECTED FREQUENCIES, UP TO        PSTAT082
C           90)                                                              PSTAT083
C     FSTRT= START FREQUENCY (IN MHZ) IF MODEF .EQ. 0                        PSTAT084
C     FSTP=STOP FREQUENCY (IN MHZ) IF MODEF .EQ. 0                           PSTAT085
C     FDEL= DELTA FREQUENCY (IN MHZ) IF MODEF .EQ. 0                         PSTAT086
C     NFO= NUMBER OF FREQUENCIES TO BE EVALUATED IF MODEF .NE. 0             PSTAT087
C     FREQJ= ARRAY TO CONTAIN USER SELECTED FREQUENCIES IF MODEF .NE. 0      PSTAT088
C     AANT= ANTENNA INDUCTION AREA (IN SQUARE METERS)                        PSTAT089
C     BNDW= RECEIVER NOISE BANDWIDTH (IN KHZ)                                PSTAT090
C     ICLO= CLOUD TYPE (1=CIRRUS, 2=STRATO CUMULUS, 4=FRONTAL SNOW)          PSTAT091
C     IC= 7 WORD ALPHANUMERIC DESCRIPTION OF CLOUD TYPE (SEE ICLO)           PSTAT092
C     CLOU= FLOATING-POINT ICLO                                              PSTAT093
C     SPDFA= SPEED FACTOR-- CHARGING CURRENT IS RELATED TO AIRCRAFT          PSTAT094
C           SPEED THROUGH THIS FUNCTION                                      PSTAT095
C     CHGC= CALCULATED CHARGING CURRENT (=DISCHARGING CURRENT) (IN AMPS)     PSTAT096
C     PROB= CALCULATED PROBABILITY OF CHARGING .GT. CHGC                     PSTAT097
C     E,W,R= WORKING STORAGE ARRAYS FOR ELEVATOR,WING, AND RUDDER            PSTAT098
C           COUPLING COEFFICIENTS (MODIFIED TO ACCOUNT FOR ANTENNA           PSTAT099
C           INDUCTION AREA)                                                  PSTAT100
C     RUDI,ELEI,WINI= DISTRIBUTION OF DISCHARGE CURRENT OVER VARIOUS         PSTAT101
C                     AIRCRAFT EXTREMITIES                                   PSTAT102
C     D2R,D2E,D2W= DISCHARGE CURRENT SPECTRUM NORMALIZERS                    PSTAT103
C     XCOU= MAXIMUM FREQUENCY OF COUPLING DATA                               PSTAT104
C     F= FREQUENCY CURRENTLY BEING EVALUATED                                 PSTAT105
C     LF= COUNTER FOR FREQJ                                                  PSTAT106
C     EX= PRESSURE COEFFICIENT   (P(TORR)=760*EX)                            PSTAT107
C     ALPHA= CORONA PULSE DECAY TIME CONSTANT                                PSTAT108
```

```
C     A= CØRØNA PULSE AMPLITUDE                                         PSTAT109
C     XNU= CØRØNA PULSE REPETITIØN RATE                                 PSTAT110
C     TEST= FREQUENCY SCALED TØ AIRCRAFT SCALE SIZE                     PSTAT111
C     ØMEGA= RADIAN FREQUENCY                                           PSTAT112
C     PREL=RELATIVE PULSE SPECTRUM AMPLITUDE                            PSTAT113
C     DØMR,DØME,DØMW= ABSØLUTE CØRØNA PULSE SPECTRUM AMPLITUDE SENSED   PSTAT114
C     IFL,IFH= FIXED PØINT LØW- AND HI-FREQ BØUNDS FØR INTERPØLATIØN    PSTAT115
C     FL,FH= FLØATING-PØINT IFL,IFH                                     PSTAT116
C     PLR,PHR= RUDDER    CØUPLING CØEFFICIENTS FØR INTERPØLATIØN BØUNDS PSTAT117
C     PLE,PHE= ELEVATØR     .        .       .       .        .         PSTAT118
C     PLW,PHW= WING         .        .       .       .        .         PSTAT119
C     RATIØ= INTERPØLATIØN SCALER                                       PSTAT120
C     PR,PE,PW= CØUPLING CØEFFICIENT INTERPØLATED TØ TEST FREQUENCY     PSTAT121
C     GØMR,GØME,GØMW= CØMPØNENT NØISE CURRENT SPECTRAL DENSITY          PSTAT122
C     BØM= RADIAN BANDWIDTH                                             PSTAT123
C     SBØM= SQRT(BØM)                                                   PSTAT124
C     SCR,SCE,SCW= CØMPØNENT SHØRT-CIRCUIT NØISE CURRENT INDUCED IN     PSTAT125
C                   ANTENNA                                             PSTAT126
C     SC= TØTAL SHØRT-CIRCUIT NØISE CURRENT (IN AMPS)                   PSTAT127
C     ENF= EQUIVALENT NØISE FIELD (VØLTS/METER)                         PSTAT128
C     FHZ= FREQUENCY (IN HZ)                                            PSTAT129
C     ENFDB= EQUIVALENT NØISE FIELD (IN DB BELØW 1 VØLT/METER)          PSTAT130
C                                                                       PSTAT131
C     CØNSTANTS AND VARIABLES PARTICULAR TØ STREAMER SECTIØN            PSTAT132
C                                                                       PSTAT133
C     DAFT= ANTENNA DISTANCE AFT ØF STREAMER SØURCE (METERS)            PSTAT134
C     IMAT= 14 CHACTER ALPHANUMERIC DESCRIPTIØN ØF STREAMER MATERIAL    PSTAT135
C     IM= MATERIAL CØDE-- 1=CANØPY,  2=RADØME                           PSTAT136
C     WX= CHARACTERISTIC DIMENSIØN ØF DIELECTRIC SURFACE (METERS)       PSTAT137
C     STRMI= STREAMER DISCHARGE CURRENT (AMPS)                          PSTAT138
C     XIM= FLØATING-PØINT MATERIAL CØDE                                 PSTAT139
C     XKV= STREAMER SPECTRUM CØNSTANT                                   PSTAT140
C     A=   STREAMER SPECTRUM CØNSTANT                                   PSTAT141
C     B=STREAMER SPECTRUM CØNSTANT                                      PSTAT142
C     ALP= STREAMER SPECTRUM CØNSTANT                                   PSTAT143
C     BET= STREAMER SPECTRUM CØNSTANT                                   PSTAT144
C     ARG=  STREAMER SPECTRUM TERM                                      PSTAT145
C     FXL=  STREAMER SPECTRUM TERM                                      PSTAT146
C     GLIT= STREAMER SPECTRUM TERM                                      PSTAT147
C                                                                       PSTAT148
C  *INPUT DATA FØRMATS ARE DESCRIBED BELØW--THE NØTATIØN IS AS FØLLØWS  PSTAT149
C         X=DIGIT IF FLØATING NUMBER IS CALLED FØR                      PSTAT150
C         N=DIGIT IF FIXED NUMBER IS CALLED FØR                         PSTAT151
C         .=DECIMAL PØINT (REQUIRED IN LØCATIØN, WHEN SHØWN)            PSTAT152
C         A=ALPHANUMERIC CHARACTER IF ALPHA WØRD IS CALLED FØR          PSTAT153
C         E=E  (REQUIRED WHEN SHØWN)                                    PSTAT154
C         S=SPACE                                                       PSTAT155
C         +=+ ØR - AS APPRØPIATE                                        PSTAT156
C         (ALL FØRMATS ILLUSTRATED BELØW ASSUME STARTING IN CØLUMN 1,   PSTAT157
C          AND SHØULD BE RIGHT-JUSTIFIED)                               PSTAT158
C      LA,LANT                                                          PSTAT159
C         =NSAAAAAAAAAAAAAA                                             PSTAT160
C         =NNNSS                                                        PSTAT161
C     NCØUP  (I3,2X)                                                    PSTAT162
```

```
C     ESTØ,WSTØ,RSTØ  (E9.2,1X,E9.2,1X,E9.2,2X)                        PSTAT163
C          =+X.XXE+NNS+X.XXE+NNS+X.XXE+NNSS                              PSTAT164
C     NRUN  (I3,2X)                                                      PSTAT165
C          =NNNSS                                                        PSTAT166
C     IØFF  (I1,2X)                                                      PSTAT167
C          =NSS                                                          PSTAT168
C      IT  (6A2,2X)                                                      PSTAT169
C          =AAAAAAAAAAAASS                                               PSTAT170
C     XN,SPD,ALT  (F5.2,1X,F6.1,1X,F4.1,2X)                              PSTAT171
C          =XX.XXSXXXX.XSXX.XSS                                          PSTAT172
C     MØDEF  (I1,2X)                                                     PSTAT173
C          =NSS                                                          PSTAT174
C     FSTRT,FSTP,FDEL  (3(F5.2,1X),1X), ØR... DAFT,W,FUSDI               PSTAT175
C          =XX.XXSXX.XXSXX.XXSS                                          PSTAT176
C     NFR  (I3,2X)                                                       PSTAT177
C          =NNNSS                                                        PSTAT178
C     FREQU  (E9.2,2X)                                                   PSTAT179
C          =+X.XXE+NNSS                                                  PSTAT180
C     AANT,BNDW  (2(F5.2,2X)) ,  ØR...  DIERAT                           PSTAT181
C          =XX.XXSSXX.XXSS                                               PSTAT182
C     ICLØ,IC  (I1,1X,7A2) ,  ØR...  IM,IMAT                             PSTAT183
C          =NSAAAAAAAAAAAAAA                                             PSTAT184
C                                                                        PSTAT185
C                                                                        PSTAT186
C                                                                        PSTAT187
C                                                                        PSTAT188
C                                                                        PSTAT189
      DIMENSIØN E(100),W(100),R(100),IT(6),IL(1),FREQU(90),LANT(7),IC(7)PSTAT190
      DIMENSIØN ESTØ(100),WSTØ(100),RSTØ(100),IMAT(7)                    PSTAT191
C                                                                        PSTAT192
C                                                                        PSTAT193
C    **FØRMATS**                                                         PSTAT194
   39 FØRMAT(6X,F6.2,6X,4(1PE10.3,7X))                                   PSTAT195
   79 FØRMAT(4A2)                                                        PSTAT196
   80 FØRMAT(I3,2X)                                                      PSTAT197
   81 FØRMAT(E9.2,1X,E9.2,1X,E9.2,2X)                                    PSTAT198
   82 FØRMAT(I1,2X)                                                      PSTAT199
   83 FØRMAT(6A2,2X)                                                     PSTAT200
   84 FØRMAT(F5.2,1X,F6.1,1X,F4.1,2X)                                    PSTAT201
   85 FØRMAT(3(F5.2,1X),1X)                                              PSTAT202
   86 FØRMAT(2(F5.2,2X))                                                 PSTAT203
   88 FØRMAT(E9.2,2X)                                                    PSTAT204
   89 FØRMAT(I1,1X,7A2)                                                  PSTAT205
  200 FØRMAT(1H1,25X,28HSRI STATIC ELECTRICITY MØDEL,///)                PSTAT206
  203 FØRMAT(4(10X,24H****DATA INPUT ERRØR****),//)                      PSTAT207
  204 FØRMAT(5X, 31HP-STATIC MØDEL EVALUATED FØR A ,6A2,9H AIRCRAFT)     PSTAT208
  205 FØRMAT(5X,10HSCALE SIZE,9X,5HSPEED,8X,8HALTITUDE,8X,10HCLØUD TYPE)PSTAT209
  206 FØRMAT(24X,5H(MPH),9X,5H(KFT),/)                                   PSTAT210
  207 FØRMAT(7X,F5.2,11X,F6.1, 10X,F4.1,10X,7A2,///)                     PSTAT211
  208 FØRMAT(5X,11HSTART FREQ.,4X,10HSTØP FREQ.,5X,7HDELTA-F)            PSTAT212
  209 FØRMAT(7X,5H(MHZ),12X,2(5H(MHZ),8X),/)                             PSTAT213
  210 FØRMAT(6X,F6.2,10X,F6.2,8X,F5.2,///)                               PSTAT214
  211 FØRMAT(5X,8HRECEIVER,10X,7HANTENNA,/,5X,5HNØISE,13X,9HINDUCTIØN,/,PSTAT215
     A  5X,9HBANDWIDTH,10X,4HAREA,/,6X,5H(KHZ),13X,6H(M**2),/)           PSTAT216
```

```
  212 FORMAT(6X,F5.2,13X,F5.2,///)
  214 FORMAT(5X,34HTHE CALCULATED CHARGING CURRENT IS,1PE10.3,1X,4HAMPS,
     A/)
  216 FORMAT(1H1)
  217 FORMAT(1H1,25X,26HSRI P-STATIC MODEL (CONTD),/)
  219 FORMAT(5X,18HTHE PROBABILITY IS,1X,F6.4,1X,25HTHAT THE CHARGING CU
     ARRENT,/,8X,20HWILL BE GREATER THAN,1PE10.3,1X,4HAMPS,//)
  218 FORMAT(2(5X,9HFREQUENCY),5X,13HSHORT-CIRCUIT,2(5X,10HEQUIVALENT),/
     A,36X,7HCURRENT,3X,2(11HNOISE FIELD,5X),/,7X,5H(MHZ),9X,4H(HZ),11X,
     B6H(AMPS),10X,9H(VOLTS/M),6X,7H(DBV/M),/)
  221 FORMAT(5X,42HWITH THE RECEIVING ANTENNA LOCATED AT THE ,4A2,//)
  223 FORMAT(6X,F6.2,10X,F6.2,5X,11HNON-UNIFORM,///)
  721 FORMAT(5X,24HALL DISCHARGES PERMITTED,///)
  722 FORMAT(5X,27HRUDDER DISCHARGE PROHIBITED,///)
  723 FORMAT(5X,30HWING TIPS DISCHARGE PROHIBITED,///)
  724 FORMAT(5X,34HELEVATOR TIPS DISCHARGE PROHIBITED,///)
  725 FORMAT(5X,43HRUDDER AND WING TIPS DISCHARGES PROHIBITED,///)
  726 FORMAT(5X,46HRUDDER AND ELEVATOR TIPS DISCHARGES PROHIBITED,///)
  727 FORMAT(5X,44HELEVATOR AND WING TIPS DISCHARGES PROHIBITED,///)
 1001 FORMAT(5X,33H FOR STREAMERING OCCURING ON THE ,7A2)
 1002 FORMAT(5X,16HAND THE ANTENNA ,F5.2,32H METERS AFT OF THE FRONT OF
     1THE ,7A2)
 1003 FORMAT(5X,42HAND A MINIMUM CHARACTERISTIC DIMENSION OF ,F5.2,26H M
     1ETERS OF THE DIELECTRIC ,7A2)
 1004 FORMAT(5X,52H AND A DIELECTRIC AREA TO A/C FRONTAL AREA RATIO OF ,
     AF5.2///)
 1006 FORMAT(5X,27HAND A FUSELAGE DIAMETER OF ,F5.2,7H METERS)
 1027 FORMAT(5X,38HTHE CALCULATED STREAMERING CURRENT IS ,1PE8.2,5H AMPS
     A,//)
C   *DEFINE CONSTANTS
C
      PI=4.0*ATAN(1.0)
      IERR=0
      EPSIL = (1.0/ (36.0*PI)) * 1.0E-09
C
C   SELECT CORONA OR STREAMERING PROGRAM OPTION
C   1=CORONA PROGRAM, 2=STREAMERING PROGRAM
C
      READ 82,NSECT
C   BRANCH TO APPROPRIATE PROGRAM SECTION
      GO TO (100,1000),NSECT
C
C
C
C   **** CORONA DISCHARGE SECTION (PROGRAM OPTION 1) ****
  100 CONTINUE
C
C   *INPUT*
C
C   READ ANTENNA LOCATION
      READ 89,LA,(LANT(J),J=1,7)
C   INPUT NUMBER OF COUPLING COEFFICIENTS TO BE READ
      READ 80, NCOUP
C   READ IN THE -NCOUP- COUPLING COEFFICIENTS
```

```
      READ 81, (ESTO(J),WSTO(J),RSTO(J),J=1,NCOUP)
C  ZERO OUT NON-USED PORTION OF ARRAYS
      NCO=NCOUP+1
      DO 1 J=NCO,100,1
      ESTO(J)=0.0
      WSTO(J)=0.0
      RSTO(J)=0.0
    1 CONTINUE
C  READ NUMBER OF PROGRAM CYCLES
      READ 80, NRUN
C  DO LOOP CONTROLS PROGRAM CYCLES
      DO 999 NRU=1,NRUN
C  READ DISCHARGE QUENCH CODE
      READ 82, IOFF
C  READ AIRCRAFT TYPE
      READ 83, (IT(J), J=1,6)
C  READ A/C SCALE SIZE, SPEED, ALTITUDE
      READ 84, XN,SPD,ALT
C  READ FREQUENCY SELECT MODE
C    MODE .EQ. 0 = UNIFORM FREQUENCY INTERVALS FROM FSTRT TO FSTP AT
C                  INTERVALS OF FDEL
C    MODE .NE. 0 = USER SELECTED FREQUENCYS (UP TO 90)
      READ 82, MODEF
C  TEST FOR MODE SELECT
      IF(MODEF) 801,802,801
C  MODE .EQ. 0, READ FSTRT,FSTP,DELTA-F (IN MHZ)
  802 READ 85, FSTRT,FSTP,FDEL
      GO TO 803
C  MODE .NE. 0, READ NUMBER OF FREQUENCYS TO BE EVALUATED
  801 READ 80, NFR
C  READ IN NFR FREQUENCY POINTS (IN MHZ)
      READ 88, (FREQL(J), J=1,NFR)
  803 CONTINUE
C  READ ANTENNA INDUCTION AREA AND RECEIVER BANDWIDTH
      READ 86, AANT, BNDW
C  READ CLOUND TYPE (1=CIRRUS, 2=STRATO CUMULUS, 4=FRONTAL SNOW)
      READ 89, ICLO, (IC(J), J=1,7)
C
C  *INPUT DATA ERROR CHECK*
C
      IF(NCOUP-100) 730,730,25
  730 IF(MODEF) 9,10,9
    9 IF(NFR-90) 10,10,25
   10 IF(IOFF-7) 11,11,25
   11 IF(ALT-90.0) 2,2,25
    2 IF(MODEF) 4,8,4
    8 DF=FSTP-FSTRT
      IF(DF) 25,25,3
    3 IF(DF-FDEL) 25,25,4
C  ALLOW ROOM TO EXPAND ERROR CHECK
   25 IERR=1
    4 CONTINUE
C
C  *PRINT INPUT DATA*
```

```
C                                                                       PSTAT325
      PRINT 200                                                         PSTAT326
      IF(IERR) 201,202,201                                              PSTAT327
  201 PRINT 203                                                         PSTAT328
  202 PRINT 204, (IT(J), J=1,6)                                         PSTAT329
      PRINT 221, (LANT(J), J=1,4)                                       PSTAT330
      PRINT 205                                                         PSTAT331
      PRINT 206                                                         PSTAT332
      PRINT 207, XN, SPD, ALT, (IC(J), J=1,7)                           PSTAT333
      PRINT 208                                                         PSTAT334
      PRINT 209                                                         PSTAT335
      IF(MODEF) 804,805,804                                             PSTAT336
  805 PRINT 210, FSTRT,FSTP,FDEL                                        PSTAT337
      GO TO 806                                                         PSTAT338
  804 PRINT 223, FREQU(1), FREQU(NFR)                                   PSTAT339
  806 CONTINUE                                                          PSTAT340
      PRINT 211                                                         PSTAT341
      PRINT 212, BNDW, AANT                                             PSTAT342
      GO TO (711,712,713,714,715,716,717), IOFF                         PSTAT343
  711 PRINT 721                                                         PSTAT344
      GO TO 718                                                         PSTAT345
  712 PRINT 722                                                         PSTAT346
      GO TO 718                                                         PSTAT347
  713 PRINT 723                                                         PSTAT348
      GO TO 718                                                         PSTAT349
  714 PRINT 724                                                         PSTAT350
      GO TO 718                                                         PSTAT351
  715 PRINT 725                                                         PSTAT352
      GO TO 718                                                         PSTAT353
  716 PRINT 726                                                         PSTAT354
      GO TO 718                                                         PSTAT355
  717 PRINT 727                                                         PSTAT356
  718 CONTINUE                                                          PSTAT357
C  IF ERROR, THEN ABORT RUN, ELSE CONTINUE                              PSTAT358
      IF(IERR) 27,26,27                                                 PSTAT359
   27 PRINT 203                                                         PSTAT360
      PRINT 216                                                         PSTAT361
      GO TO 999                                                         PSTAT362
   26 PRINT 217                                                         PSTAT363
C  COMPUTE THE TOTAL CHARGING CURRENT TO THE AIRCRAFT                   PSTAT364
      CLOU=FLOAT(ICLO)                                                  PSTAT365
      SPDFA=((-2.354E-09)*(SPD**3)) + (4.876E-06)*(SPD**2) +(6.65E-04)*SPSTAT366
     APD                                                                PSTAT367
      CHGC= 6.0757E-04*SPDFA*CLOU*XN                                    PSTAT368
      IF(CHGC-1.E-03) 700,700,701                                       PSTAT369
  700 PROB=2.0/(CHGC*1.E+06)                                            PSTAT370
      GO TO 702                                                         PSTAT371
  701 PROB=2.0E+06/((CHGC*1.0E+06)**3)                                  PSTAT372
  702 IF(ALT-20.0) 704,704,705                                          PSTAT373
  704 PROB=PROB*CLOU*ALT/20.0                                           PSTAT374
      GO TO 706                                                         PSTAT375
  705 PROB=PROB*CLOU*20.0/ALT                                           PSTAT376
  706 CONTINUE                                                          PSTAT377
      PRINT 214, CHGC                                                   PSTAT378
```

```
      PRINT 219, PROB,CHGC
      PRINT 218
C
C  *BEGIN CALCULATION*
C
C  SCALE COUPLING COEFFICIENTS BY INDUCTION AREA
      DO 32 J=1,NCOUP
      E(J)=ESTO(J)*AANT
      W(J)=WSTO(J)*AANT
      R(J)=RSTO(J)*AANT
   32 CONTINUE
C     SCALE COUPLING COEFFICIENTS BY SCALE SIZE UNLESS ANTENNA IS
C            LOCATED AT OR NEAR A GIVEN EXTREMITY
      SCAFAC=(1.0/XN)**(2.5)
      IF(LA)3110,3110,3009
 3009 GO TO (3111,3112,3113,3110),LA
 3111 DO 3120 J=1,NCOUP
      W(J)=W(J)*SCAFAC
      R(J)=R(J)*SCAFAC
 3120 CONTINUE
      GO TO 3114
 3112 DO 3121 J=1,NCOUP
      E(J)=E(J)*SCAFAC
      R(J)=R(J)*SCAFAC
 3121 CONTINUE
      GO TO 3114
 3113 DO 3122 J=1,NCOUP
      E(J)=E(J)*SCAFAC
      W(J)=W(J)*SCAFAC
 3122 CONTINUE
      GO TO 3114
 3110 DO 3123 J=1,NCOUP
      E(J)=E(J)*SCAFAC
      W(J)=W(J)*SCAFAC
      R(J)=R(J)*SCAFAC
 3123 CONTINUE
 3114 CONTINUE
C  SCALE COMPONENT DISCHARGE CURRENTS
      RUDI=0.182*CHGC
      ELEI=0.364*CHGC
      WINI=0.454*CHGC
C  CALCULATE COMPONENT SPECTRUM NORMALIZERS
      D2R=1.037E-06*SQRT(RUDI)
      D2E=1.037E-06*SQRT(ELEI)
      D2W=1.037E-06*SQRT(WINI)
C  INITIALIZE FREQUENCY AND PRESSURE PARAMETERS
      XCOU=FLOAT(NCOUP)-1.0
      IF(MODEF) 815,816,815
  816 F=FSTRT
      GO TO 817
  815 LF=1
      F=FREQU(LF)
  817 CONTINUE
      EX=EXP(-((ALT + 0.002*(ALT**2))/25.))
```

```
      ALPHA= 2.111111E+07*EX
      A=7.053457E+05*((760.0*EX)**(-0.25))
      XNU=3.83767E+03*((760.0*EX)**(0.48))
C  BEGIN FREQUENCY DEPENDENT CALCULATIØN
   35 CØNTINUE
      TEST=XN*F
      IF(TEST - XCØU) 36, 36, 38
   38 CALL ØVER
      GØ TØ 999
   36 ØMEGA=2.0*PI*F*1.0E+06
      PREL=A*SQRT(XNU/PI)/SQRT((ØMEGA**2) + (ALPHA**2))
      DØMR=D2R*PREL
      DØME=D2E*PREL
      DØMW=D2W*PREL
C  CALCULATE SCALED CØUPLING CØEFFICIENTS
      IFL=IFIX(TEST)
      IFH=IFL + 1
      FL=FLØAT(IFL)
      FH=FL + 1.0
      PLR=R(IFL+1)
      PHR=R(IFH+1)
      PLE=E(IFL+1)
      PHE=E(IFH+1)
      PLW=W(IFL+1)
      PHW=W(IFH+1)
      RATIØ=(TEST-FL)/(FH-FL)
      PR=PLR + (PHR-PLR)*RATIØ
      PE=PLE + (PHE-PLE)*RATIØ
      PW=PLW + (PHW-PLW)*RATIØ
C  CØMPUTE RØØT(G(ØMEGA))
      GØMR=PR*DØMR
      GØME=PE*DØME
      GØMW=PW*DØMW
C  CØMPUTE SHØRT-CIRCUIT NØISE CURRENT
      BØM=2.0*PI*BNDW*1000.0
      SBØM=SQRT(BØM)
      SCR=GØMR*SBØM
      SCE=GØME*SBØM
      SCW=GØMW*SBØM
      GØ TØ(308,302,303,304,305,306,307),IØFF
  302 SCR=SCR/100.0
      GØ TØ 308
  303 SCW=SCW/100.0
      GØ TØ 308
  304 SCE=SCE/100.0
      GØ TØ 308
  305 SCR=SCR/100.0
      SCW=SCW/100.0
      GØ TØ 308
  306 SCR=SCR/100.0
      SCE=SCE/100.0
      GØ TØ 308
  307 SCE=SCE/100.0
      SCW=SCW/100.0
```

```
      GO TO 308                                                         PSTAT487
  308 CONTINUE                                                          PSTAT488
C  COMPUTE TOTAL SHORT-CIRCUIT NOISE CURRENT                            PSTAT489
      SC=SQRT((SCR**2) + (SCE**2) + (SCW**2))                           PSTAT490
C  COMPUTE EQUIVALENT NOISE FIELD                                       PSTAT491
      ENF=SC/(OMEGA*EPSIL*AANT)                                         PSTAT492
      FHZ=F*1.0E+06                                                     PSTAT493
      ENFDB=20.0*ALOG(ENF)/2.303                                        PSTAT494
C  OUTPUT RESULTS                                                       PSTAT495
      PRINT 33, F,FHZ,SC,ENF,ENFDB                                      PSTAT496
C  INCREMENT F AND TEST FOR FREQ RANGE COMPLETE                         PSTAT497
      IF(MODEF) 820,821,820                                             PSTAT498
  821 F=F+FDEL                                                          PSTAT499
      IF(F-FSTP) 35,35,40                                               PSTAT500
  820 LF=LF+1                                                           PSTAT501
      F=FREQU(LF)                                                       PSTAT502
      IF(LF-NFR) 35,35,40                                               PSTAT503
   40 GO TO 999                                                         PSTAT504
C                                                                       PSTAT505
C                                                                       PSTAT506
C                                                                       PSTAT507
C  **** STREAMERING SECTION (PROGRAM OPTION 2) ****                     PSTAT508
 1000 CONTINUE                                                          PSTAT509
C  *** INPUT ***                                                        PSTAT510
C                                                                       PSTAT511
C  READ IN ANTENNA LOCATION                                             PSTAT512
      READ 79, (LANT(J),J=1,4)                                          PSTAT513
C  READ AIRCRAFT TYPE                                                   PSTAT514
      READ 83,  (IT(J),J=1,6)                                           PSTAT515
C  READ A/C SCALE SIZE, SPEED, ALTITUDE                                 PSTAT516
      READ 84,XN,SPD,ALT                                                PSTAT517
C  READ FREQUENCY SELECT MODE                                           PSTAT518
C  MODE .EQ.0 = UNIFORM FREQUENCY INTERVALS FROM FSTRT TO FSTP AT       PSTAT519
C                INTERVALS OF FDEL                                      PSTAT520
C  MODE .NE.0 = USER SELECTED FREQUENCIES (UP TO 90)                    PSTAT521
      READ 82,MODEF                                                     PSTAT522
C  TEST FOR MODE SELECT                                                 PSTAT523
      IF(MODEF) 1801,1802,1801                                          PSTAT524
CC  MODE .EQ.0, READ FSTRT,FSTP,DELTA-F (IN MHZ)                        PSTAT525
 1802 READ 85,FSTRT,FSTP,FDEL                                           PSTAT526
      GO TO 1803                                                        PSTAT527
C  MODE .NE.0, READ NUMBER OF FREQUENCIES TO BE EVALUATED               PSTAT528
 1801 READ 80,NFR                                                       PSTAT529
C  READ IN NFR FREQUENCY POINTS (IN MHZ)                                PSTAT530
      READ 88,(FREQU(J),J=1,NFR)                                        PSTAT531
 1803 CONTINUE                                                          PSTAT532
C  READ ANTENNA INDUCTION AREA AND RECEIVER BANDWITH                    PSTAT533
      READ 86,AANT,BNDW                                                 PSTAT534
C  READ CLOUD TYPE (1=CIRRUS, I=STRATO CUMULUS, 4=FRONTAL SNOW)         PSTAT535
      READ 89,ICLO,(IC(J),J=1,7)                                        PSTAT536
C  READ IN CHARGING MATERIAL CODE AND MATERIAL                          PSTAT537
C  MATERIAL CODE 1=WINDSHIELD, 2=RADOME                                 PSTAT538
      READ 89,IM,(IMAT(J),J=1,7)                                        PSTAT539
C  READ IN ANTENNA DISTANCE (METERS) AFT OF RADOME OR WINDSHIELD        PSTAT540
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C   AND MINIMUM CHARACTERISTIC DIMENSION OF DIELECTRIC SURFACE (METERS)  PSTAT541
C   AND FUSELAGE DIAMETER (METERS)                                        PSTAT542
      READ 85, DAFT,WX,FUSDI                                              PSTAT543
C   READ IN RATIO OF DIELECTRIC AREA TO AIRCRAFT FRONTAL AREA             PSTAT544
      READ 86,DIERAT                                                      PSTAT545
C                                                                         PSTAT546
C     ** PRINT INPUT DATA **                                              PSTAT547
C                                                                         PSTAT548
      PRINT 200                                                           PSTAT549
      PRINT 204,(IT(J),J=1,6)                                             PSTAT550
      PRINT 231,(LANT(J),J=1,4)                                           PSTAT551
      PRINT 1001,(IMAT(J),J=1,7)                                          PSTAT552
      PRINT 1002,DAFT,(IMAT(J),J=1,7)                                     PSTAT553
      PRINT 1003, WX,(IMAT(J), J=1,7)                                     PSTAT554
      PRINT 1006, FUSDI                                                   PSTAT555
      PRINT 1004,DIERAT                                                   PSTAT556
      PRINT 205                                                           PSTAT557
      PRINT 206                                                           PSTAT558
      PRINT 207,XN,SPD,ALT,(IC(J),J=1,7)                                  PSTAT559
      PRINT 208                                                           PSTAT560
      PRINT 209                                                           PSTAT561
      IF(MODEF) 1804,1805,1804                                            PSTAT562
 1805 PRINT 210,FSTRT,FSTP,FDEL                                           PSTAT563
      GO TO 1806                                                          PSTAT564
 1804 PRINT 223,FREQU(1),FREQU(NFR)                                       PSTAT565
 1806 CONTINUE                                                            PSTAT566
      PRINT 211                                                           PSTAT567
      PRINT 212,BNDW,AANT                                                 PSTAT568
      PRINT 217                                                           PSTAT569
C   COMPUTE THE TOTAL CHARGING CURRENT TO THE AIRCRAFT                    PSTAT570
      CLOU=FLOAT(ICLO)                                                    PSTAT571
      SPDFA=((-2.354E-09)*(SPD**3))+(4.876E-06)*(SPD**2)+6.65E-04*SPD     PSTAT572
      CHGC= 6.0757E-04*SPDFA*CLOU*XN                                      PSTAT573
      IF(CHGC-1.E-03) 1700,1700,1701                                      PSTAT574
 1700 PROB=2.0/(CHGC*1.E+06)                                              PSTAT575
      GO TO 1702                                                          PSTAT576
 1701 PROB=2.0E+06/((CHGC*1.0E+06)**3)                                    PSTAT577
 1702 IF(ALT-20.0) 1704,1704,1705                                         PSTAT578
 1704 PROB=PROB*CLOU*ALT/20.0                                             PSTAT579
      GO TO 1706                                                          PSTAT580
 1705 PROB=PROB*CLOU*20.0/ALT                                             PSTAT581
 1706 CONTINUE                                                            PSTAT582
      PRINT 214,CHGC                                                      PSTAT583
      PRINT 219,PROB,CHGC                                                 PSTAT584
C   COMPUTE STREAMER CHARGING CURRENT                                     PSTAT585
      TEMP=DIERAT*CHGC                                                    PSTAT586
      GO TO (1710,1711),IM                                                PSTAT587
 1710 TEMP=TEMP*0.5                                                       PSTAT588
 1711 STRMI=TEMP                                                          PSTAT589
      PRINT 1027, STRMI                                                   PSTAT590
      PRINT 218                                                           PSTAT591
C                                                                         PSTAT592
C   ** BEGIN STREAMER NOISE CALCULATION **                                PSTAT593
C                                                                         PSTAT594
```

```
C   CØNVERT DIELECTRIC PARAMETERS TØ FEET FRØM METERS
          DAFT=DAFT/0.3076
          FUSDI=FUSDI/0.3076
C   CØMPUTE CØUPLING FUNCTIØN PSI
          IF(DAFT) 1712,1713,1712
 1713     PSI=3.0
          GØ TØ 1717
 1712     GØ TØ (1716,1715), IM
 1715     PSIØNA=1.20E-02/(DAFT*FUSDI)
          PSI=PSIØNA*AANT
          GØ TØ 1717
 1716     PSIØNA=((DAFT)**(-4))*0.096+6.6E-05
          PSI=PSIØNA*AANT
 1717     CØNTINUE
C  INITIALIZE FREQUENCY PARAMETERS
          IF(MØDEF) 1815,1816,1815
 1816     F=FSTRT
          GØ TØ 1817
 1815     LF=1
          F=FREQU(LF)
 1817     CØNTINUE
          XIM=0.01
          XKV=1.27E+05
          XNU=STRMI/(1.5E-09)
          A=0.597
          B=0.403
          ALP=1.67E+07
          BET=3.47E+06
C   BEGIN FREQUENCY DEPENDENT CALCULATIØN
 1835     ØMEGA=2.0*PI*F*1.0E+06
C   CØMPUTE F(X,L)
          ARG=WX*ØMEGA/(2.0*XKV)
          FXL=2.0*PSI*PSI*(1.0-(SIN(ARG)/ARG))
C   CØMPUTE LITTLE G(ØMEGA)
          T1=(ØMEGA**2)*((A+B)**2)
          T2=((A*BET+B*ALP)**2)
          B1=ALP*ALP+(ØMEGA**2)
          B2=BET*BET+(ØMEGA**2)
          GLIT=(T1+T2)/((ØMEGA**2)*B1*B2)
C   CØMPUTE BIG G (ØMEGA)
          GØM=XNU*XIM*XIM*XKV*XKV*GLIT*FXL/PI
C   CØMPUTE SHØRT CIRCUIT CURRENT (SC)
          BØM=2.0*PI*BNDW*1000.0
          SBØM=SQRT(BØM)
          RGØM=SQRT(GØM)
          SC=SBØM*RGØM
C   CØMPUTE EQUIVALENT NØISE FIELD
          IF(DAFT) 1903,1904,1903
 1903     ENF=SC/(ØMEGA*EPSIL*AANT)
 1904     CØNTINUE
C   SETUP ØUTPUT AND PRINT RESULTS
          FHZ=F*1.0E+06
          IF (DAFT) 1900,1901,1900
 1901     PRINT 39, F,FHZ, SC
```

```
      GO TO 1902                                                        PSTAT649
 1900 ENFDB=20.0*ALOG(ENF)/2.303                                        PSTAT650
      PRINT 39,F,FHZ,SC,ENF,ENFDB                                       PSTAT651
C  INCREMENT F AND TEST FOR FREQUENCY RANGE COMPLETE                    PSTAT652
 1902 CONTINUE                                                          PSTAT653
      IF(MODEF) 1820,1821,1820                                          PSTAT654
 1821 F=F+FDEL                                                          PSTAT655
      IF(F-FSTP) 1835,1835,999                                          PSTAT656
 1820 LF=LF+1                                                           PSTAT657
      F=FREQU(LF)                                                       PSTAT658
      IF(LF-NFR) 1835,1835,999                                          PSTAT659
  999 CONTINUE                                                          PSTAT660
      STOP                                                              PSTAT661
      END                                                               PSTAT662
      SUBROUTINE OVER                                                   PSTAT663
      PRINT 1                                                           PSTAT664
    1 FORMAT(     45HCOUPLING DATA NON-EXISTENT BEYOND LAST LISTED,/)   PSTAT665
      RETURN                                                            PSTAT666
      END                                                               PSTAT667
```

REFERENCES

1. H. G. Hucke, "Precipitation Static Interference," Proc. IRE, Vol. 27, No. 5 (May 1939).

2. R. C. Ayers and J. O. Jarrard, "Aircraft Precipitation Static Investigation," Contract W 33-106 SC-70, Trans-World Airlines, Inc. (August 1944).

3. R. Gunn et al., "Army-Navy Precipitation Static Project," Proc. IRE, Vol. 34, Nos. 4 and 5 (1946).

4. R. L. Tanner and J. E. Nanevicz, "Precipitation Charging and Corona-Generated Interference in Aircraft," AFCRL 336, Tech. Report 73, Contract AF 19(604)-3458, SRI Project 2494, Stanford Research Institute, Menlo Park, Calif. (April 1961), AD-261 029.

5. R. L. Tanner and J. E. Nanevicz, "An Analysis of Corona-Generated Interference in Aircraft," Proc. IEEE, Vol. 52, No. 1, pp. 44-52 (January 1964).

6. R. L. Tanner and J. E. Nanevicz, "Radio Noise Generated on Aircraft Surfaces," Final Report, Contract AF 33(616)-2761, SRI Project 1267, Stanford Research Institute, Menlo Park, Calif. (September 1956).

7. J. E. Nanevicz, "A Study of Precipitation-Static Noise Generation in Aircraft Canopy Antennas," Tech. Report 62, Contract AF 19(604)-1296, SRI Project 1197, Stanford Research Institute, Menlo Park, Calif. (December 1957).

8. R. L. Tanner, "Radio Interference from Corona Discharges," Tech. Report 37, Contract AF 19(604)-266, SRI Project 591, Stanford Research Institute, Menlo Park, Calif. (April 1953).