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A General Numerical Analysis Program for the Superconducting Quasiparticle Mixer

Ross G. Hicks, Marc J. Feldman,
and Anthony R. Kerr

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Ross G. Hicks, Marc J. Feldman,
and Anthony R. Kerr
NASA Goddard Institute for Space Studies
New York, New York

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and Space Administration
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ABSTRACT

This report describes a user oriented computer program SISCAP (SIS Computer Analysis Program) for analyzing SIS mixers. The program allows arbitrary impedance terminations to be specified at all LO harmonics and sideband frequencies. It is therefore able to treat a much more general class of SIS mixers than the widely used three-frequency analysis, for which the harmonics are assumed to be short-circuited. An additional program, GETCHI, provides the necessary input data to program SISCAP.

The program SISCAP performs a nonlinear analysis to determine the SIS junction voltage waveform produced by the local oscillator. The quantum theory of mixing is used in its most general form, treating the large signal properties of the mixer in the time domain. A small signal linear analysis is then used to find the conversion loss and port impedances. The noise analysis, includes thermal noise from the termination resistances and shot noise from the periodic LO current. Quantum noise is not considered.

Many aspects of the program have been adequately verified and found accurate. However, this project was terminated before the program was extensively employed, and it is possible that errors may occur in various untested parameter ranges.

An example is given, which forms part of some initial investigations into the effect of decreasing the SIS junction capacitance on the performance of a simple SIS mixer circuit. Early indications are that, for this circuit, a high $\omega_p R_N C_J$ product is desirable.

LIST OF SYMBOLS USED IN THIS REPORT

B	bandwidth
β	thermal energy parameter ($1/kT$)
C_J	SIS parasitic junction capacitance
Δ	energy gap parameter
δ	Kronecker delta function
δI	small signal current flowing in SIS junction
$\delta I'$	small signal current in augmented small signal circuit
δV	small signal voltage across SIS junction
δi_T	thermal noise current
δi_S	shot noise current
$\delta t'$	time increment
δV	voltage increment
e	electronic charge
f	cycle frequency
\hbar	Planck's constant divided by 2π
I_{KK}	Kramers-Kronig function
I_{DC}	DC SIS tunnel junction current flowing in absence of LO
I^{NL}	nonlinear SIS large signal current
I^{LIN}	linear large signal current
I_n^{LIN}	n th Fourier harmonic of I^{LIN}
J	SIS small signal response function
k	Boltzmann's constant
L_{ij}	conversion loss to i -th sideband from the j -th sideband
m	index parameter

m	frequency index
M	numerical accuracy parameter
P	convergence parameter for voltage update method
P_0	noise power out
ϕ	barrier phase
Q	numerical accuracy parameter
R_{ID}	identity element resistance for voltage update method
R_N	normal state SIS resistance
τ	SIS normalized time response parameter
t	time
T	SIS physical temperature
T_M	mixer input noise temperature
T_{DSB}	mixer input double sideband noise temperature
T_{SSB}	mixer input single sideband noise temperature
U	large signal SIS time domain response variable
V	SIS tunnel junction voltage
V^\dagger	updated SIS tunnel junction voltage
V_n	n th Fourier harmonic of V
V_{N_0}	noise output voltage
V_{LO}	LO source voltage
V_{DC}	DC source voltage
V_{gap}	SIS gap voltage
V_{TOTAL}	total voltage range required of discretized I-V curve
W_{LO}	small signal analysis variable
ω_p	angular LO frequency
ω	Fourier transform variable

ω_m	m-th sideband frequency
χ	SIS junction impulse response
Y	small signal intrinsic admittance matrix
Y'	small signal augmented admittance matrix
Z'	small signal augmented impedance matrix
Z_e	embedding impedance
Z_c	impedance of the SIS junction capacitance C_J
Z_0	transmission line impedance for multiple reflection technique
Z_m	input impedance of the mixer at the m-th sideband
Z'_0	center row of small signal impedance matrix

2. Introduction

As a result of work by Tucker [1] on the quantum theory of mixing, it is now possible to predict the performance of SIS (superconductor-insulator-superconductor) quasi-particle mixers with reasonable accuracy. This theory has been quantitatively verified in its three frequency approximate form [2]. The purpose of this report is to make available a user oriented computer program SISCAP (SIS Computer Analysis Program) for determining the performance of an SIS mixer with arbitrary terminations at the LO (local oscillator) harmonics and harmonic sidebands. The program uses the Tucker theory in its most general form. It is much more versatile than earlier analyses which employed the three-frequency approximation, for which all LO harmonics above the fundamental and sidebands above the upper sideband of the LO fundamental are assumed short-circuited.

The general outline of this report follows that of a similar work by Siegel and Kerr [3], which described a computer program to analyze Schottky diode mixers using classical mixer theory. Reference [3] has proved very valuable in the analysis of Schottky mixers, and it is hoped that this report will serve the same purpose for SIS mixers.

The mixer analysis program SISCAP is subdivided into three parts. The most difficult part of the program is the nonlinear large signal analysis which is used to determine the LO voltage waveform at the junction. This analysis is done iteratively to find a self-consistent solution and requires a significant amount of CPU time. Following the nonlinear analysis, a linear small signal analysis computes the conversion loss between the input (signal) and output (IF) ports as well as the input

and output impedance match. Finally, the program determines the equivalent input noise temperature of the SIS mixer. As an additional feature, this computer program performs the three frequency model analysis if desired. The run time for the example listed in Section A.3 is 0.5 mins. on an AMDAHL V6.

Although this report is written explicitly for a mixer using single SIS junctions, the program may be used to analyze any single-particle tunneling device in the quantum regime whose I-V curve is resistive at large voltages. In particular, the program reduces a series array of SIS junctions to its single junction equivalent by assuming the junctions are identical. In any situation however, the DC I-V curve must always be a monotonic function and the user should ensure that experimental measurement errors do not violate this requirement.

This report also describes the program GETCHI, which must be run prior to SISCAP. GETCHI processes an experimental SIS DC I-V curve to provide input data for SISCAP in proper form, and determines the value of various control parameters for SISCAP. Further information on this program is given in Section 3. An empirical study of the digitization constraints required to maintain numerical errors to an acceptably low value is also described.

1.1 SIS Junctions: Definition of Terms

This work is not meant to be a general reference on the theory and operation of SIS mixers. It is assumed that the reader has a solid working knowledge of this topic, and explicit detail is given only where necessary to describe the computer program and the choices made in its design. For general reference, the reader is referred to a recent review paper [4].

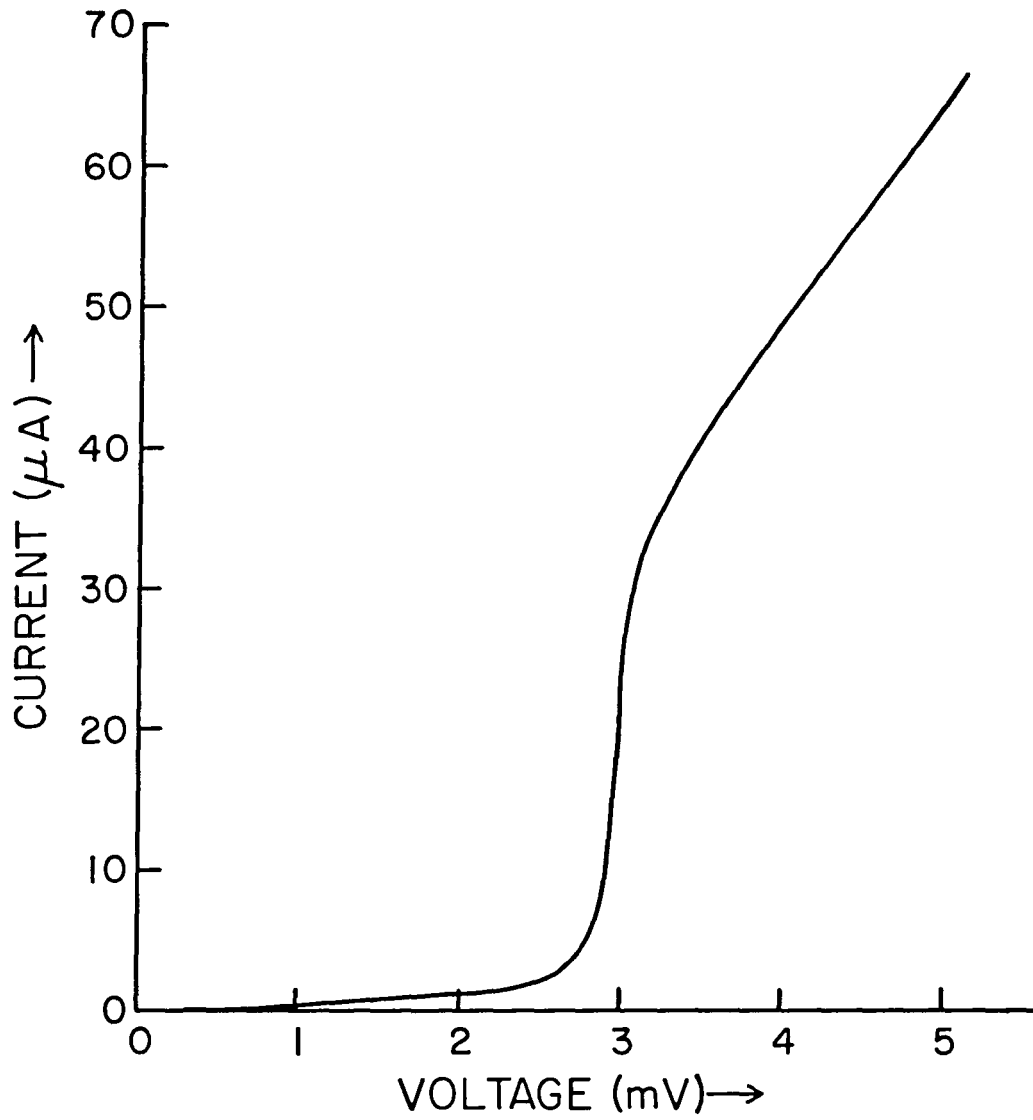


Fig. 1: Typical SIS DC I-V Curve

This section outlines the terms and symbols to be used in this report. The units used here are SI units. A typical quasiparticle DC I-V curve of an SIS junction is shown in Fig. 1. Note that, for this program, superconducting pair tunneling currents are ignored. The rapid rise in current seen in Fig. 1 occurs at the gap voltage V_{gap} , which is related to the energy gap parameter Δ by the formula:

$$V_{\text{gap}} = \frac{2\Delta}{e} \quad (1)$$

At large DC bias voltages, the I-V curve approaches the resistance R_N , which is also the resistance of the junction in the normal state. The SIS junction has the geometrical form of a parallel plate capacitor, whose capacitance C_J acts to shunt the nonlinear quasiparticle current.

In order to describe mathematically the behaviour of the SIS junction, the time domain equations given by Tucker [1] will be used:

$$I^{\text{NL}}(t) = \frac{V(t)}{R_N} + \text{Im} \left\{ U^*(t) \int_{-\infty}^t \chi(t-t') U(t') dt' \right\} \quad (2)$$

$$\chi(t) = \frac{2}{\pi} \int_0^{\infty} \left[I_{\text{DC}} \left(\frac{\hbar\omega}{e} \right) - \frac{\hbar\omega}{eR_N} \right] \sin\omega t \, d\omega \quad (3)$$

$$U(t) = \exp\{i\phi(t)\} \quad (4)$$

$$\phi(t) = -\frac{e}{\hbar} \int_{-\infty}^t V(t') dt' \quad (5)$$

Eq. (1) gives the instantaneous quasiparticle current $I^{\text{NL}}(t)$ as a function of the junction voltage V at all time t . The impulse response function $\chi(t)$ of the SIS junction is related to the nonlinear DC I-V curve through

the sine Fourier transform as shown in Eq. (3). $U(t)$ represents the driving force applied to the junction and is related via the barrier phase $\phi(t)$ to the instantaneous voltage $V(t)$ in Eqs. (4) and (5).

For the small signal analysis, the SIS junction is treated in the frequency domain. The general frequency domain I-V relation is the Fourier transform of Eq. (2), which is complex. The appropriate small signal response function is then:

$$J(v) = I_{KK}(v) + i I_{DC}(v) \quad (6)$$

$$\text{where } I_{KK}(v) = P \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{\left[I_{DC}(V) - \frac{V}{R_N} \right]}{V - v} dv \quad (7)$$

Finally, the problem of analyzing series arrays must be considered. A property of arrays is that their saturation power level increases as N^2 , where N is the number of junctions in the array. The conversion gain and noise temperature are independent of N , both in theory [4] and apparently in experiment [5]. Because of these useful properties, the program described in this report has been written to analyze such arrays. The array is reduced to its single junction equivalent on the assumption of identical junctions, by dividing both the current and the voltage of the array DC I-V curve by N [5].

2. Outline of the Necessary Theory

Given the bias voltage, LO amplitude and the DC I-V curve, an SIS mixer analysis should output the following quantities: conversion loss, input impedance, output impedance and mixer noise temperature. These quantities will be calculated by a small signal analysis once the large signal voltage and current waveforms at the SIS junction are known. The first step in the mixer analysis algorithm therefore is to determine these waveforms.

2.1 Large Signal Analysis

The most difficult part of this project is the large signal nonlinear analysis. All of the Fourier coefficients of the LO waveform must be determined in a self-consistent manner. Several papers have appeared in the literature on this problem in the context of the Schottky diode mixer. Early workers such as Torrey and Whitmer [6] assumed the voltage across the diode junction to be sinusoidal, with the implication that the harmonics of the local oscillator were short circuited. Fleri and Cohen [7] removed this assumption but their work was restricted to simple lumped element embedding networks. More realistic embedding networks were analyzed by Egami [8] and by Gwarek [9], using harmonic balance techniques. However, these schemes frequently had difficulty converging for some circuits of practical interest. In particular, the method of Egami [8] tended to diverge when more than three harmonic terms were considered, and the convergence of the method of Gwarek [9] was a strong function of the initial solution estimates.

In a bid to overcome these convergence deficiencies, Kerr [10] developed the multiple reflection technique, in which a

hypothetical lossless transmission line of arbitrary characteristic impedance is introduced between the nonlinear diode and the linear circuit elements. This method converges in all cases tested and the convergence rate [11] depends upon how close the harmonic embedding impedances are to the characteristic impedance of the transmission line. There is no dependence upon one's estimate of the initial conditions.

Another technique, developed by Hicks and Khan [11,12], consists of two dual methods, the voltage update and the current update methods. This has also converged for all cases tested, and the rate of convergence depends upon the proximity of the embedding impedances at each LO harmonic to either short circuits or open circuits. In both this technique and the multiple reflection method, the algorithm operates in the time domain when considering the nonlinearity and in the frequency domain when dealing with the linear embedding network.

Most practical SIS mixers have rather large junction capacitances ($\omega_p R_N C_J^1$ products are usually in the range 1 to 10), and so the embedding impedance seen by the nonlinear junction conductance approaches a short circuit with increasing frequency. This condition therefore lends itself to the use of the voltage update method of Hicks and Khan [11] and this method has been adopted for use in the program SISCAP. Such a choice will lead to a rapid convergence rate. Moreover, the use of the voltage update method permits the nonlinear SIS equations to be solved in their simplest form. This is a voltage-input-current-output mode, and requires only a direct calculation from the SIS equations. The multiple reflection technique requires the SIS nonlinear equations to be solved on a

¹ ω_p = angular pump frequency, R_N = normal-state resistance of the SIS device and C_J = junction capacitance.

current-input-voltage-output basis, which adds an extra iteration loop to the process. To improve convergence further, the voltage update program can incorporate a parallel identity resistance technique as outlined in [11]. Typically, identity resistances of the order of $0.5R_N$ have been found to give satisfactory performance.

Finally, for additional flexibility, the multiple reflection method [10] has also been added to this program as an additional option in the large signal analysis section and should be used where low $\omega_p R_N C_J$ products (less than 0.5) are encountered. In such cases, considerable experience is necessary for correct use of the voltage update method and the relatively "hands free" multiple reflection technique is preferable.

2.1.1 Solution of the Large Signal Problem

The equivalent circuit of the mixer is shown in Fig. 2. For analysis of this mixer, the circuit is bisected at the linear-nonlinear interface with each half treated separately. The junction capacitance, C_J , is treated as being part of the linear circuit.

The expressions governing the behaviour of the intrinsic² SIS junction are given by Tucker [1] in the time domain as follows:

$$I^{NL}(t) = \frac{V(t)}{R_N} + \text{Im} \left\{ U^*(t) \int_{-\infty}^t \chi(t-t') U(t') dt' \right\} \quad (2)$$

$$\chi(t) = \frac{2}{\pi} \int_0^{\infty} \left[I_{DC} \left(\frac{\hbar\omega}{e} \right) - \frac{\hbar\omega}{eR_N} \right] \sin\omega t d\omega \quad (3)$$

$$U(t) = \exp\{i\phi(t)\} \quad (4)$$

²The expression intrinsic junction is used in this paper to refer to the nonlinear tunneling admittance of the junction, considered separate from the junction capacitance.

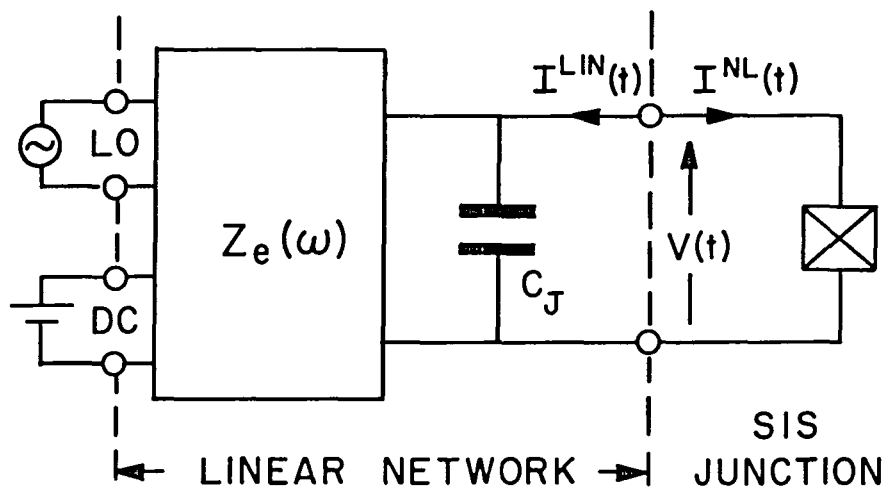


Fig. 2: SIS Mixer Equivalent Circuit

$$\phi(t) = -\frac{e}{\hbar} \int_{-\infty}^t V(t') dt' \quad (5)$$

where I_{DC} (V) is the measured DC I-V characteristic of the SIS junction with no LO power applied;

R_N is the normal resistance of the junction;

$V(t)$ is the instantaneous voltage across the junction; and

$I^{NL}(t)$ is the instantaneous quasiparticle tunneling junction.

The conditions imposed on the steady state response of the mixer circuit by the embedding network can be more conveniently expressed in the frequency domain. Referring to Fig. 2:

$$\frac{V_n}{I_n^{LIN}} = [Z_e(n\omega_p) // Z_c(n\omega_p)] \quad n = 2, 3, \dots \quad (8)$$

$$\frac{V_1 - V_{LO}}{I_1^{LIN}} = [Z_e(\omega_p) // Z_c(\omega_p)] \quad (9)$$

$$\frac{V_0 - V_{DC}}{I_0^{LIN}} = [Z_e(0)] \quad (10)$$

where V_n and I_n^{LIN} are the amplitudes of the Fourier components of $V(t)$ and $I^{LIN}(t)$ at frequency $n\omega_p$, V_{LO} and V_{DC} are the amplitudes of the Thevenin equivalent LO and DC voltage sources, and $Z_e(n\omega_p)$ is the impedance of the equivalent external embedding circuit at frequency $n\omega_p$, and $Z_c(n\omega_p) = -i/n\omega_p C_J$.

2.1.2 Voltage Update Algorithm

The iterative voltage update algorithm [11] works as follows:

- (i) An initial estimate is made of the large signal steady state voltage waveform across the nonlinear tunnel junction, $V(t)$;
- (ii) Eqs. (2) - (5) are used to determine the current $I^{NL}(t)$ which is produced by the voltage $V(t)$ across the intrinsic junction;
- (iii) Using Kirchhoff's current law, $I^{LIN}(t) = -I^{NL}(t)$;
- (iv) A fast Fourier transform gives $I^{LIN}(\omega)$ from $I^{LIN}(t)$;
- (v) This current, $I^{LIN}(\omega)$, which flows into the embedding network, must be maintained by a voltage $V^\dagger(\omega)$ whose various Fourier components are given by Eqs. (8) - (10);
- (vi) Using an inverse fast Fourier transform, $V^\dagger(t)$ is obtained from $V^\dagger(\omega)$;
- (vii) $V^\dagger(t)$ and $V(t)$ are compared; if "equal", the iteration is complete. If not, a new $V(t)$, equal to $pV^\dagger(t) + (1-p)V(t)$, is defined, and the cycle repeated from step (ii). The convergence parameter, p , is normally a value in the range $0 < p \leq 1$ [11].

This procedure is called the "voltage update method", because the mechanism for approaching the self-consistent solution in a controllable fashion is the updating of the junction voltage waveform with each iteration in step (vii). It may be shown [11] that this method converges when, at all the harmonics of interest, the magnitude of the impedance of the linear embedding network is smaller than the magnitude of the

impedance of the nonlinear circuit. This is the case in an SIS mixer by virtue of the junction capacitance, considered here as part of the embedding network. The value of the parameter, p , is chosen on the basis of previous experience [11]. Essentially, its value represents a tradeoff between speed of convergence and the risk of divergence. In this work, p was fixed at unity since the use of an identity element (to be discussed below) proves sufficient to guarantee convergence.

The computer program allows parallel resistive identity elements [11] to be inserted at the linear-nonlinear interface. A resistive identity element consists of the parallel combination of a resistance R_{ID} and a resistance $-R_{ID}$. The net effect of the two parallel resistances on the circuit performance is zero since one cancels the effect of the other. However, in the large signal analysis, convergence is improved since the resistance R_{ID} is lumped in parallel with the linear embedding network and in a similar manner, the resistance $-R_{ID}$ is added in parallel with the nonlinear circuit [11]. The effect of such an addition is to enhance the voltage update properties of the circuit by increasing the effective impedance of the tunnel junction and simultaneously decreasing the input impedance of the embedding network. From experience, setting R_{ID} equal to $0.5R_N$ has been found effective.

2.1.3 Multiple Reflection Technique

The multiple reflection algorithm [10] provides an alternative to the voltage update technique discussed in the previous section. In this method, a lossless transmission line of characteristic impedance, Z_0 , is inserted at the linear-nonlinear interface. Its length is an integral number of L_0 wavelengths. The steady state operation of the modified

network is identical to that of the original circuit, but the approach to steady state differs from that of the original circuit. Also, because the solution approaches steady state in a physically realizable way, the multiple reflection method should not be susceptible to numerical instability.

The iterative procedure proceeds as follows:

(i) A right propagating wave from a source impedance Z_0 is emitted from the embedding network and impinges on the SIS device. From the nonlinear circuit equations, the periodic voltage and current produced by the incident wave at the SIS device terminals may be calculated.

(ii) The nonlinear SIS junction generates a left propagating wave containing, in general, all harmonics of the LO. After a delay, the left propagating wave impinges on the embedding network.

(iii) From the reflection coefficient of the embedding network, a new right propagating wave may be deduced.

This iterative cycle of steps (i) - (iii) continues until convergence is reached. At convergence, the SIS junction voltage waveform remains unchanged with increasing iteration number. This method should converge for any value of Z_0 , the transmission line characteristic impedance, although the rate of convergence is affected. Typically, Z_0 equal to R_N has been found to give good results.

2.2 Small Signal Analysis

The small signal analysis follows precisely the theory as formulated by Held and Kerr [13] for the analysis of Schottky diode mixers, with the conversion admittance matrix elements given by Tucker [1]. The small signal and noise theory given here is based largely on reference [14].

Using the results of the large signal analysis together with a knowledge of the embedding impedances at the various sideband frequencies, a linear small signal conversion admittance matrix may be formulated for the mixer. This matrix gives the relationships between the small signal sideband currents and voltages at the nonlinear element, and hence gives all the small signal properties of the mixer.

2.2.1 Frequency and Subscript Notation

If a mixer is pumped at frequency ω_p and has an intermediate frequency ω_0 , then, under the linear assumption, the only small signals which can produce an IF response are at the sideband frequencies $\omega_0 + m\omega_p$, $m = 0, \pm 1, \pm 2, \dots$. Following Saleh [15] it is useful to define the sideband frequencies by:

$$\omega_m = \omega_0 + m\omega_p \quad m = 0, \pm 1, \pm 2, \pm 3, \dots \quad (11)$$

It may be seen that lower sideband frequencies are represented by negative terms ($m < 0$). A brief comment on the meaning of these negative frequency terms is given in the footnote.³

Saleh's frequency notation leads to a considerable simplification of the mathematics of mixer theory. Using this notation all upper sideband frequencies ($\omega_0 + |m|\omega_p$) are considered positive, while all lower sideband frequencies ($\omega_0 - |m|\omega_p$) are negative. The sideband frequency index m is

³Electrical quantities are frequently described by a single complex quantity associated with some frequency, assumed positive. For example, a voltage of frequency ω may be described simply by its complex half-amplitude V , implying an instantaneous voltage $v(t) = V e^{j\omega t} + V^* e^{-j\omega t}$. It is just as meaningful to work with a negative frequency ($-\omega$) and the conjugate of the complex half-amplitude (V^*), provided the convention is clearly understood. Impedances and admittances are then simply the conjugates of their conventional positive frequency values, i.e. $Z(-\omega) = V^*/I^* = Z^*(\omega)$.

used as a subscript to the various electrical quantities and hence the upper sideband, intermediate, and lower sideband frequencies are:

$\omega_{+1} = \omega_0 + \omega_p$, ω_0 , and $\omega_{-1} = \omega_0 - \omega_p$; and V_{+1} , V_0 and V_{-1} represent voltages at these frequencies.

2.2.2 Small Signal Conversion Matrix

Using the sideband notation described in the previous section, let $\hat{\delta I}$ and $\hat{\delta V}$ denote the vectors of the small signal sideband currents (δI_n) and voltages (δV_n) at the terminals of the intrinsic SIS junction. Then

$$\hat{\delta I} = [\dots, \delta I_1, \delta I_0, \delta I_{-1}, \dots]^T \quad (12)$$

and

$$\hat{\delta V} = [\dots, \delta V_1, \delta V_0, \delta V_{-1}, \dots]^T . \quad (13)$$

Torrey and Whitmer [6] have shown that $\hat{\delta I}$ and $\hat{\delta V}$ are related via a conversion admittance matrix \hat{Y} defined by

$$\hat{\delta I} = \hat{Y} \hat{\delta V} . \quad (14)$$

If the row and column numbering of the square matrix \hat{Y} correspond with the sideband numbering, \hat{Y} can be written out as:

$$\begin{array}{ccccccc}
& & & \cdot & \cdot & \cdot & \\
& & & \cdot & \cdot & \cdot & \\
\hat{Y} & = & \cdot & \cdot & Y_{11} & Y_{10} & Y_{1-1} & \cdot & \cdot \\
& & \cdot & \cdot & Y_{01} & Y_{00} & Y_{0-1} & \cdot & \cdot \\
& & \cdot & \cdot & Y_{-11} & Y_{-10} & Y_{-1-1} & \cdot & \cdot \\
& & & \cdot & \cdot & \cdot & & & \\
& & & \cdot & \cdot & \cdot & & &
\end{array} \quad (15)$$

with element values given by [1]:

$$\begin{aligned}
Y_{mm'} &= (-i) \frac{e}{2\hbar\omega_{m'}} \sum_{n, n'=-\infty}^{\infty} W_{LO}(n\omega_p) W_{LO}^*(n'\omega_p) \delta_{m-m', n'-n} \\
&\quad \{ [J(n\omega_p + eV_0/\hbar) - J(n\omega_p - \omega_{m'} + eV_0/\hbar)] \\
&\quad - [J^*(n'\omega_p + \omega_{m'} + eV_0/\hbar) - J^*(n'\omega_p + eV_0/\hbar)] \}
\end{aligned} \quad (16)$$

where W_{LO} is defined by:

$$\exp\left\{-i \frac{e}{\hbar} \int_{-\infty}^t [V(t') - V_0] dt'\right\} = \sum_{n=-\infty}^{\infty} W_{LO}(n\omega_p) e^{-in\omega_p t} \quad ; \quad (17)$$

$V(t)$ is the instantaneous large signal voltage across the tunnel junction;

δ is the Kronecker delta function;

J is defined in Section 2.2.5;

V_0 is the DC component of the junction waveform; and

* denotes the complex conjugate operation.

The matrix \hat{Y} can be regarded as the admittance matrix of a multifrequency multiport network, as shown in Fig. 3, in which there is one port for every sideband frequency ω_m . If the parallel combination of the embedding impedances and the parasitic junction capacitive impedance, $Z_{e_m} // Z_{c_m}$, corresponding to the sideband frequencies, ω_m , are now connected in parallel with the intrinsic junction, an augmented network is formed as shown by the broken line in Fig. 3. The ports of the augmented network correspond to the terminals of the intrinsic SIS junction at the various sideband frequencies and do not represent physically accessible ports in the real mixer. The augmented network can be described by the admittance matrix \hat{Y}' , defined by:

$$\hat{\delta I}' = \hat{Y}' \hat{\delta V} \quad (18)$$

where

$$\hat{\delta I}' = [\dots, \delta I'_1, \delta I'_0, \delta I'_{-1}, \dots]^T$$

and

$$\hat{\delta V} = [\dots, \delta V_1, \delta V_0, \delta V_{-1}, \dots]^T, \quad (19)$$

δV_m and $\delta I'_m$ are the small signal voltage and current components, at sideband $\omega_m = \omega_0 + m\omega_p$ (port m) of the augmented network. The elements of the augmented admittance matrix \hat{Y}' are given by:

$$Y'_{mn} = Y_{mn} \quad m \neq n \quad (20a)$$

and

$$Y'_{mm} = Y_{mm} + [Z_{e_m} // Z_{c_m}]^{-1}, \quad m = n \quad (20b)$$

Inverting (18) gives

$$\hat{\delta V} = \hat{Z}' \hat{\delta I}', \quad (21)$$

where

$$\hat{Z}' = (\hat{Y}')^{-1}. \quad (22)$$

The impedance matrix \hat{Z}' enables us to calculate the conversion loss and the input and output impedances of the mixer and is also needed in computing the noise temperature.

2.2.3 Mixer Port Impedances

The impedance Z_m of any port of the intrinsic SIS junction (see Fig. 3) can be found by open circuiting the corresponding embedding impedance Z_e and then forming the \hat{Z}' matrix defined by (21). The desired port impedance is given by the mm -th element of the newly formed \hat{Z}' matrix:

$$Z_m = Z'_{mm, \infty} \quad , \quad (23)$$

where the subscript ∞ indicates that \hat{Z}' has been formed with Z_{e_m} open circuited. In such an operation, the corresponding mixer input impedance seen by the embedding circuit therefore is:

$$Z_{in_m} = Z_m = Z'_{mm, \infty} \quad . \quad (24)$$

In particular, the IF output impedance is given by:

$$Z_{IF_{out}} = Z_{in_0} = Z_0 = Z'_{00, \infty} \quad . \quad (25)$$

2.2.4 Conversion Loss

The conversion loss from sideband j to sideband i in a mixer is

$$L_{ij} = \left(\frac{\Delta \text{ power available from the signal source at sideband } \omega_j}{\text{converted power from the signal source, delivered to the load at sideband } \omega_i} \right) .$$

Consider for the moment only the intrinsic SIS junction shown in Fig. 3.

The power available from impedance $(Z_{e_j} // Z_{c_j})$ at the j -th sideband is

$$P_{available} = 1/4 |\delta I'_j|^2 \text{Re}[Z_{e_j} // Z_{c_j}] \quad . \quad (26)$$

The power delivered to a load impedance $(Z_{e_i} // Z_{c_i})$ at sideband i is, using (21):

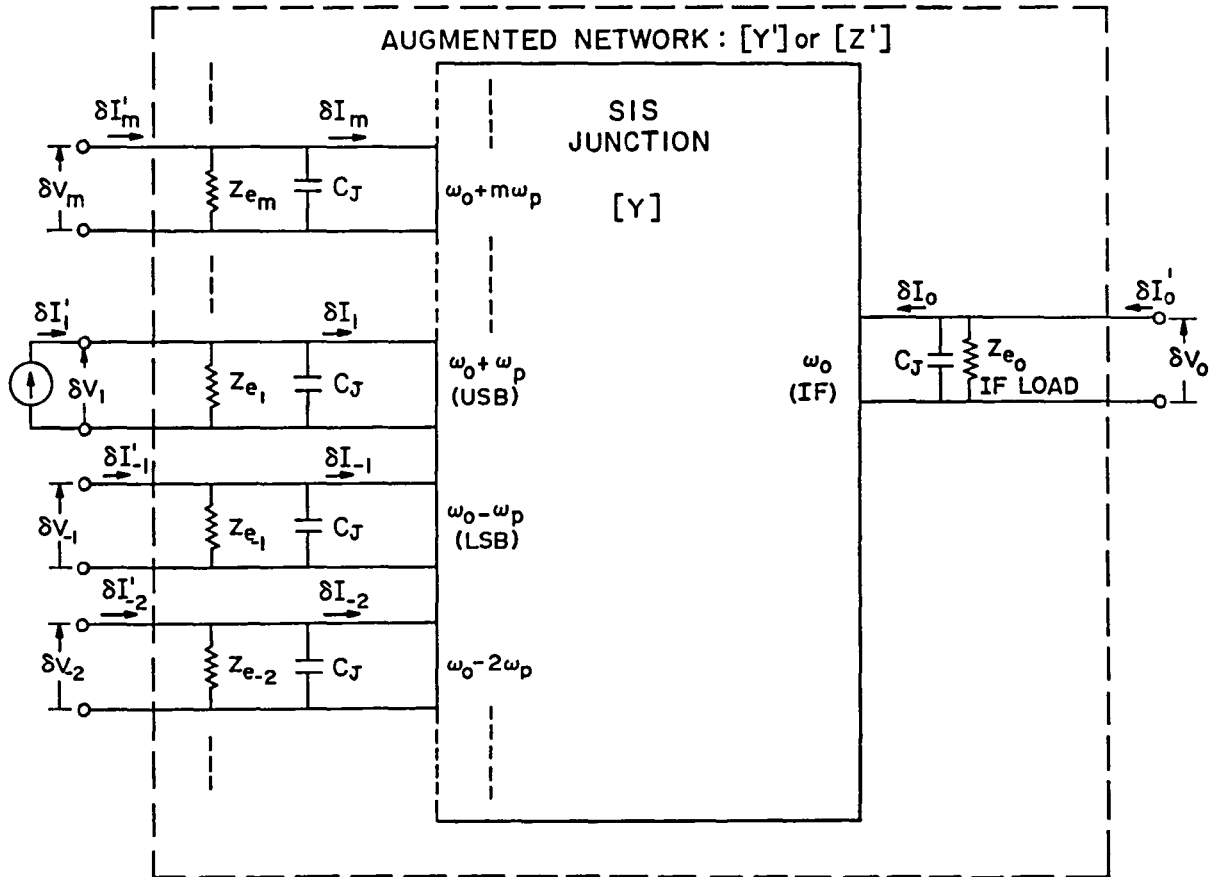


Fig. 3: Multifrequency Multiport Equivalent Small Signal Circuit

$$P_{\text{delivered}} = \frac{|z_{ij}'|^2 |\delta I_j'|^2 \operatorname{Re}[z_{e_i} // z_{c_i}]}{|z_{e_i} // z_{c_i}|^2} \quad (27)$$

Dividing (26) by (27) gives the conversion loss L'_{ij} of the intrinsic tunnel junction:

$$\frac{P_{\text{available}}}{P_{\text{delivered}}} = L'_{ij} = \frac{|z_{e_i} // z_{c_i}|^2 |z_{e_j} // z_{c_j}|^2}{4 |z_{ij}'|^2 \operatorname{Re}[z_{e_j} // z_{c_j}] \operatorname{Re}[z_{e_i} // z_{c_i}]} \quad (28)$$

The conversion loss of the actual mixer, L_{ij} , is equal to L'_{ij} since the linear parasitic junction capacitance dissipates no power.

2.2.5 Calculation of J

The value of the function J is required in the calculation of the small signal conversion parameters. J is a complex function of a real argument, defined as:

$$J(v) = I_{KK}(v) + i I_{DC}(v) \quad (6)$$

where $i = \sqrt{-1}$, $I_{DC}(v)$ is the current in the SIS junction at DC voltage v , and I_{KK} is the Kramers-Kronig transform of I_{DC} , defined mathematically as follows:

$$I_{KK}(v) = P \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{\left[I_{DC}(V) - \frac{V}{R_N} \right]}{V - v} dV \quad (7)$$

The following properties of Eq. (7) are worth noting:

- (i) The Kramers-Kronig transform is identical to the Hilbert transform [16].
- (ii) Note that Eq. (7) contains a singularity at $V = v$. To enable a finite integration to be calculated, the Cauchy principal value is used wherein the singularity is approached equally from both directions on the V axis.

(iii) The ohmic portion of the I-V characteristic is subtracted out of the numerator of the integrand in the above integral such that the integral is finite. Fig. 4 shows the area under the I-V curve is infinite unless the linear or ohmic portion is removed. The linear or ohmic portion of the DC I-V curve contributes only a constant term to the value of I_{KK} . As only subtractions of I_{KK} terms are relevant to the calculation of the value of the mixer properties, the linear portion of the DC I-V curve may be subtracted out without error [17].

(iv) The calculation of the Kramers-Kronig transform does not proceed directly according to the definition given above in Eq. (7), but via the Fourier transform as follows [16]:

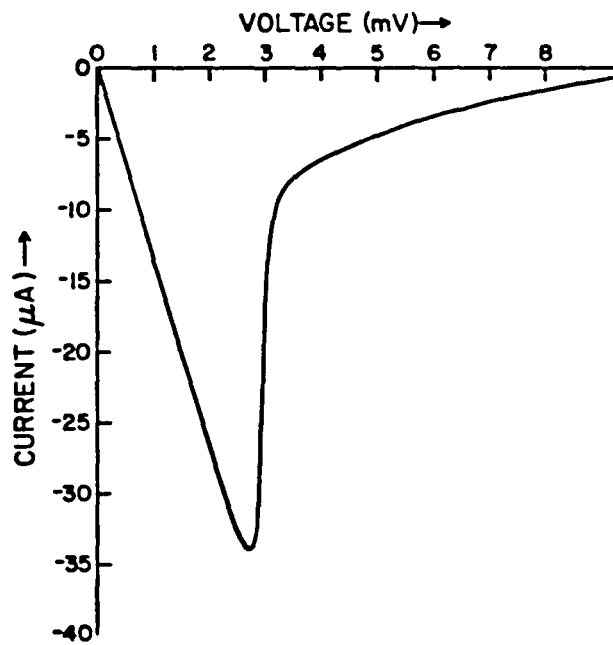
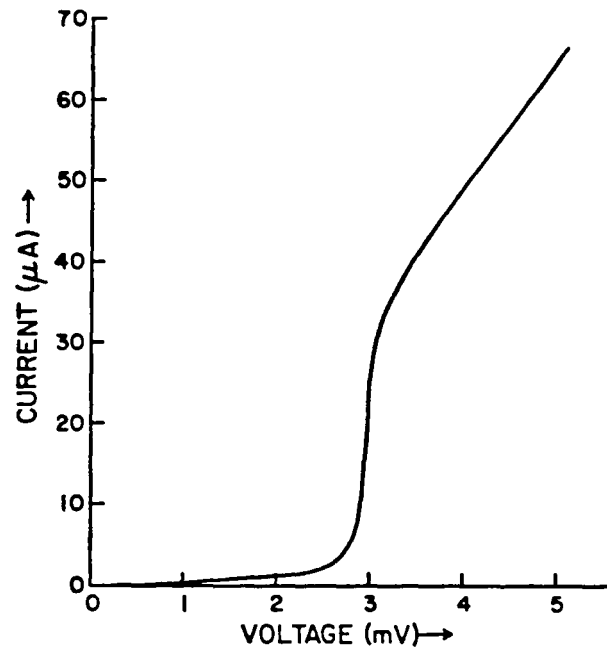


Fig. 4: (a) SIS DC I-V Curve; (b) Same I-V Curve With Ohmic Portion Removed.

- (i) Form the Fourier transform of the function $[I_{DC} - \frac{V}{R_N}]$;
- (ii) For values in the positive Fourier domain, multiply by $-i$; for values in the negative Fourier domain, multiply by $+i$;
- (iii) Invert the resulting transform using a fast Fourier transform.

This method represents a significant saving in CPU time, particularly in view of the need for fast Fourier transform routines in other parts of the computer programs GETCHI and SISCAP.

2.3 Mixer Noise Theory

The noise observed in a SIS tunnel junction comes from three sources:

- (i) shot noise due to the statistical nature of the current flow across the junction, (ii) thermal noise due to the random motion of the charge carriers in the embedding network, and (iii) quantum noise, which occurs by virtue of the zero point energy.

A theory capable of predicting the contribution of the quantum noise in a circuit analysis computer program has yet to be derived. Indeed, the problem of quantum noise in tunnel junction mixers, discussed in Refs. [4] and [18], has not been clearly resolved, and it will be ignored here. General considerations [19] require that a "high gain linear amplifier", such as the SIS mixer, add at least a half photon of fluctuation energy, referred to its input, to any incoming signal. This results in a minimum noise temperature $T_m = \hbar\omega/2k$, which is small at the frequencies of interest (2.8K at 115GHz).

The equivalent circuit of the SIS tunnel junction, including noise sources, is shown in Fig. 5. $\overline{\delta i_T^2}$ and $\overline{\delta i_S^2}$ are the mean-square values of the thermal and shot noise currents in the frequency range f to $f + \Delta f$. These current sources can be regarded as generating a multitude of quasi-sinusoidal frequency components, each with its own amplitude and phase. In the multifrequency multiport equivalent circuit of the mixer (Fig. 3), the noise sources can be included by connecting a noise current source at each sideband frequency to the appropriate port of the augmented network.

2.3.1 Thermal Noise

Thermal noise generated in any embedding resistance has components which are uncorrelated at the various sideband frequencies. Let $\delta I'_{T_m}$ represent the quasi-sinusoidal component at sideband frequency ω_m of the thermal noise current source in Fig. 5 and let δV_{T_m} be the sideband noise voltage produced by $\delta I'_{T_m}$. The noise voltage produced at the IF port of the augmented network (Fig. 3) by the thermal noise at all the sidebands can be found using Eq. (21):

$$\delta V_{T_0} = \hat{Z}'_0 \hat{\delta I}'_T, \quad (29)$$

where $\hat{\delta I}'_T = [\dots, \delta I'_{T_1}, \delta I'_{T_0}, \delta I'_{T_{-1}}, \dots]$ is the vector of input thermal noise currents at the sideband ports of Fig. 3 and \hat{Z}'_0 is the center row of the augmented impedance matrix \hat{Z}' . From (29):

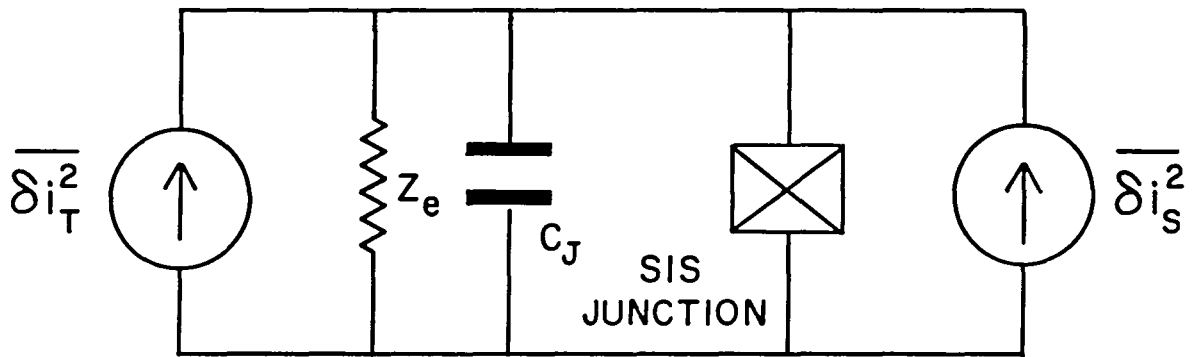


Fig. 5: SIS Noise Equivalent Circuit

$$\delta v_{T_0} \cdot \delta v_{T_0}^* = \hat{Z}'_0 \hat{\delta I}'_T \cdot (\hat{Z}'_0 \hat{\delta I}'_T)^\dagger = \hat{Z}'_0 \hat{\delta I}'_T \hat{\delta I}'_T{}^\dagger \hat{Z}'_0{}^\dagger. \quad (30)$$

where \dagger implies the complex conjugate transpose of the vector. Taking the ensemble average gives:

$$\langle |\delta v_{T_0}|^2 \rangle = \hat{Z}'_0 \langle \hat{\delta I}'_T \hat{\delta I}'_T{}^\dagger \rangle \hat{Z}'_0{}^\dagger. \quad (31)$$

The square matrix $\langle \hat{\delta I}'_T \hat{\delta I}'_T{}^\dagger \rangle$ is the thermal noise current correlation matrix. Since the thermal noise components at the various sideband frequencies are uncorrelated, the matrix is diagonal. Including the Planck quantum correction to the Rayleigh-Jeans blackbody formula, this matrix is:

$$\langle \delta I'_{T_m} \delta I'_{T_{m'}}{}^\dagger \rangle = 0 \quad m \neq m' \quad (32a)$$

$$\langle \delta I'_{T_m} \delta I'_{T_m}{}^\dagger \rangle = \frac{4\hbar\omega_m B \operatorname{Re}(1/Z_{e_m})}{[\exp(\hbar\omega_m/kT) - 1]} \quad \text{for } m = m' \quad (32b)$$

2.3.2 Shot Noise

The shot noise in a mixer arises from the current produced in the tunnel junction conductance by the local oscillator and DC bias. The formal derivation for the output shot noise follow the thermal noise derivation. The mean square shot noise voltage produced at the IF port of the mixer is given by an equation analogous to Eq. (31) but with subscript T replaced by subscript S.

The shot noise can be considered as white (Gaussian) noise, amplitude modulated by the LO waveform. Dragone [20] and Uhlir [21] have investigated the properties of this modulated noise and have shown that there is a partial correlation between the quasi-sinusoidal components at the various sideband frequencies. The correlated components at these sidebands are down converted in the diode to the intermediate frequency where they add vectorially. Therefore, the shot noise current correlation matrix is not diagonal. It is given by Tucker [1] for quantum mixer theory as follows:

$$\begin{aligned} \langle \delta I'_{S_m} \delta I'^{\dagger}_{S_{m'}} \rangle &= e \sum_{n, n'=-\infty}^{\infty} W_{LO}(n\omega) W_{LO}^*(n'\omega) \delta_{m-m', n'-n} \\ &\quad \{ \coth[\beta(eV_0 + n'\hbar\omega + \hbar\omega_{m'})/2] I_{DC}(V_0 + n'\hbar\omega/e + \hbar\omega_{m'}/e) \\ &\quad + \coth[\beta(eV_0 + n\hbar\omega - \hbar\omega_{m'})/2] I_{DC}(V_0 + n\hbar\omega/e - \hbar\omega_{m'}/e) \} \quad (33) \end{aligned}$$

where $\beta = 1/kT$.

2.3.3 Total Mixer Noise

The total output noise of the mixer is obtained by combining the thermal and shot noise components:

$$\langle |V_{N_0}|^2 \rangle = \hat{Z}'_0 [\langle \hat{\delta I}'_S \hat{\delta I}'^{\dagger}_S \rangle + \langle \hat{\delta I}'_T \hat{\delta I}'^{\dagger}_T \rangle] \hat{Z}'^{\dagger}_0 \quad (34)$$

The noise power delivered to the IF load from the mixer is:

$$P_0 = \langle |V_{N_0}|^2 \rangle \operatorname{Re}[Z_{e_0}] / |Z_{e_0}|^2 \quad (35)$$

The equivalent input noise temperature T_M of the mixer is the temperature to which the signal source conductance must be heated to give the same output noise from a noiseless but otherwise identical mixer as the actual mixer would produce when its signal source conductance was maintained at absolute zero temperature. Thus,

$$T_M \triangleq P_0 L_{01}/k_B \quad . \quad (36)$$

Note that Eq. (36) does not use the quantum corrected form of Johnson noise. The quantum corrected form used as an alternate definition would give a slightly different numerical result. In either case the noise power is unambiguous.

T_M , as defined above, is the single sideband noise temperature, T_{SSB} . When describing the performance of a mixer whose physical input port is coupled to both the signal and image frequencies, it is more convenient to talk in terms of a double sideband noise temperature T_{DSB} . T_{DSB} is the temperature to which the signal and image source conductances must be heated to give the same output noise from a noiseless but otherwise identical mixer as the actual mixer would produce when its signal and image source conductances were maintained at absolute zero temperature. For mixers in which the conversion loss from the signal and image frequencies, L_{01} and L_{0-1} , are equal:

$$T_{DSB} = T_{SSB}/2 \quad (37)$$

and in general when $L_{01} \neq L_{0-1}$

$$T_{DSB} = \frac{T_{SSB}}{1 + \frac{L_{01}}{L_{0-1}}} \quad (38)$$

2•4 Comment on the Effect of Various Program Control Parameters

In transforming these procedures into a workable computer program, there is a practical limit on the number of harmonics of the local oscillator which can be computed in the nonlinear large signal analysis. Also, the small signal admittance matrix \hat{Y} will be truncated above some finite sideband number.

For the voltage update large signal analysis, this truncation is equivalent to terminating the intrinsic junction in a short circuit at all frequencies higher than the truncation frequency. For a large enough number of harmonics, this approximation is reasonable since the $\omega_p R_N C_J$ product of the junction is usually greater than unity. These same remarks apply to the truncation of the small signal admittance conversion matrix \hat{Y} .

For the multiple reflection large signal analysis, the justification for the truncation is not so clear. In this method, the truncation is equivalent to terminating the intrinsic SIS junction in the characteristic impedance of the transmission line at higher frequencies. Although the parasitic capacitance clearly leads to short circuit terminations at these higher harmonics, it has been found in practice that the errors so caused by the truncation are not significant.

It should be noted that, in spite of the high $\omega_p R_N C_J$ products, a large number of points (e.g. 64 harmonics of 113.9GHz LO) still needs to be considered by the program since the intrinsic response of the junction is still exceptionally fast (e.g. 0.5 psec rise time for 3mV gap voltage

device). However, embedding impedance measurements do not have to be made right up to the 64th harmonic, since the shorting effect of the junction capacitance say above the 10th harmonic makes the mount impedance external to the capacitance irrelevant; the junction merely sees a short circuit. The number of harmonics treated in the program is automatically equal to one half of the number of time intervals into which each LO cycle is divided (Sec. 3.4. v.i).

2.5 Nonlinear SIS Device Equation Calculations

Three problems arise in putting the nonlinear quasiparticle current-voltage equation,

$$I^{NL}(t) = \frac{V(t)}{R_N} + \text{Im} \left\{ U^*(t) \int_{-\infty}^t \chi(t-t') U(t') dt' \right\} \quad (39)$$

in a form suitable for numerical solution. These are:

- (i) How to approximate the lower limit of $-\infty$ in the integration;
- (ii) How small must the increment $\delta t'$ be ($\delta t'$ is the numerical approximation to dt'); and
- (iii) As the two terms on the right hand side of the above equation are approximately equal in magnitude and opposite in sign for all DC bias voltages below the energy gap voltage, relative errors in I^{NL} are likely to be large in this region.

The problem of the lower limit of $-\infty$ is identical to the problem of deciding how much of χ is required before its asymptotically decreasing contributions at higher arguments are insignificant. The solution to this

problem is obtained by numerically evaluating $\int_0^M \chi(t) dt$ and $\int_0^{2M} \chi(t) dt$. M is changed until the two integrals agree with each other to within 0.1%. This procedure was done for both an ideal SIS junction and also a typical real SIS junction. The results of this investigation are as follows:

$$M_{\text{ideal}} > 95 \tau \quad (40)$$

$$M_{\text{real}} > 16 \tau \quad (41)$$

where $\tau = \frac{h}{2\Delta}$ is a normalizing time constant, with $h = \text{Planck's constant}$ and $\Delta = \text{the energy gap}$. It is emphasized that the value of M_{real} will depend on the sharpness of the DC I-V curve of the device to be analyzed. The curve so used to obtain the value of 16τ was relatively sharp as may be seen in Fig. 6. Should a user have a significantly sharper DC I-V curve, then by trial and error, the value of the program control parameter NOCHI should be varied to obtain the appropriate value.

It should be noted at this stage that the integral to be evaluated is $\int_{-\infty}^t \chi(t-t') U(t') dt'$ and not $\int_0^{\infty} \chi(t') dt'$ as used above. By experiment, it has been found that selecting a lower limit based on an 0.1% error in the latter integral leads to no more than 0.1% error in the former.

The second problem, the size of δt , is solved in the following manner. The following two numerical integrals, expressed as sums, are computed:

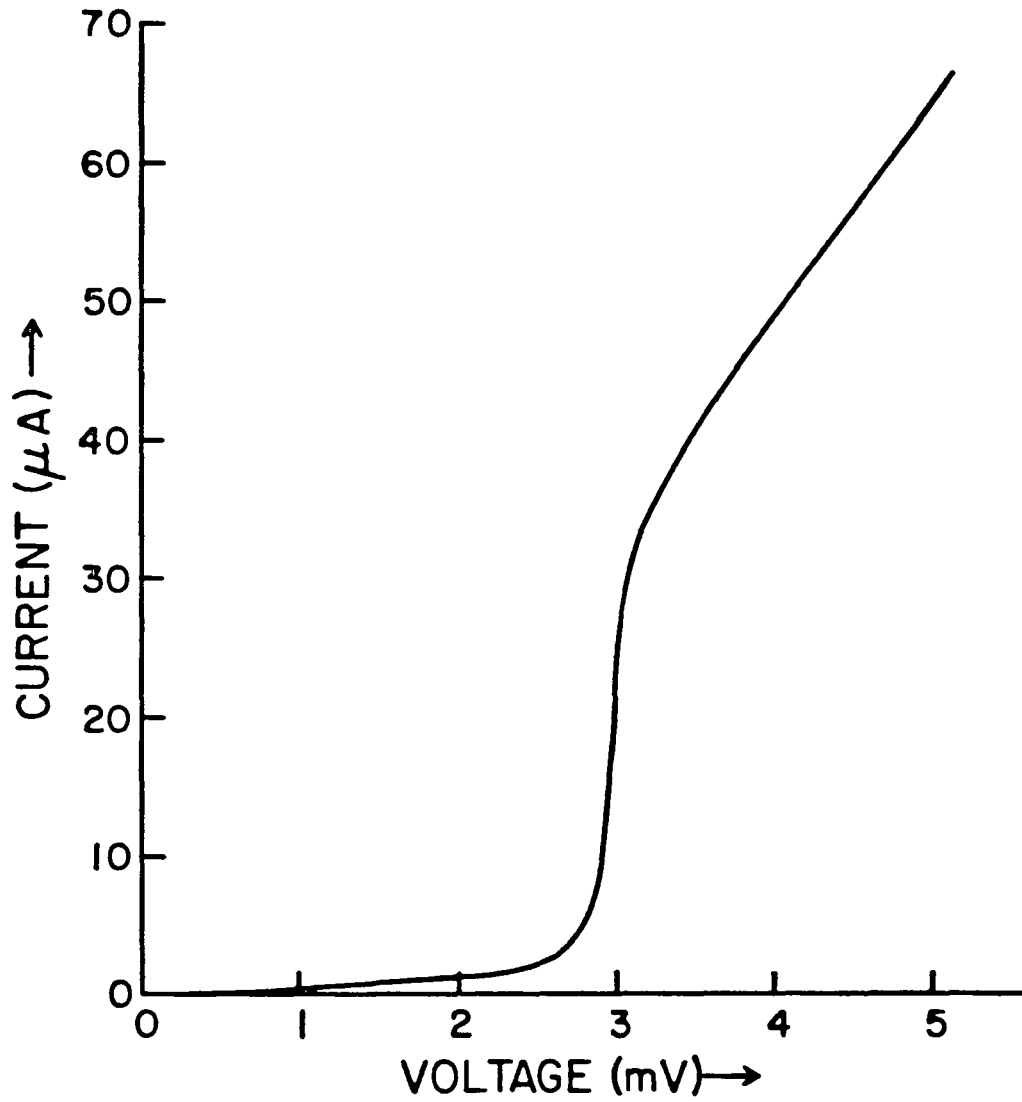


Fig. 6: I-V Curve Used to Determine Numerical Constraint Parameters in Section 2.5

$$\sum_{k=1}^N \chi(k\delta t) \delta t \quad \text{as} \quad \sum_{k=1}^{2N} \chi\left(\frac{k\delta t}{2}\right) \frac{\delta t}{2}$$

δt is adjusted until the two sums are within 0.1% of each other. The value obtained for δt is the same for both real and ideal SIS DC I-V curves, since the rise time of the χ function in each case is the same. The value of δt obtained is:

$$\frac{\delta t}{\tau} < 0.064 \quad (42)$$

for both real and ideal SIS DC I-v curves.

The third problem with the nonlinear SIS circuit equation lies in the addition of the two nearly equal and opposite terms. These terms, for voltages below the energy gap, are approximately equal in magnitude but opposite in sign. This is so since the sum must equal the leakage current in the case of zero LO power applied. Even with LO power applied, the DC pumped current is often of the same order of magnitude as the leakage current.

The following table indicates the accuracy required in calculating the term $Q = \text{Im}\left\{U^*(t) \int_{-\infty}^t \chi(t-t') U(t') dt'\right\}$ to ensure a 1% error bound in $I^{NL}(t)$ for the SIS junction of Fig. 6:

VOLTAGE	% MAX ERROR IN Q
1mV	0.0062
2mV	0.024
3mV	0.66
4mV	0.86
5mV	0.92
6mV	0.94

TABLE 1

As expected, the error requirements on Q are most severe in the areas below the energy gap if a constant percentage error is to be maintained in $I^{NL}(t)$. However, it would seem intuitively correct that we could relax the percentage error in $I^{NL}(t)$ for very low values of $I^{NL}(t)$ without appreciably affecting the calculated conversion loss or noise temperature of the mixer.

A summary of the digitization constraints on χ based on this discussion is given in Table 2, for a real and the ideal SIS I-V curves. For comparison, the values required to perform an analogous time-domain analysis of the ideal Josephson pair tunneling currents, from Gayley [22], are also presented.

	IDEAL SIS	REAL SIS	IDEAL JOSEPHSON[22]
M	95τ	16τ	80τ
δt	0.064τ	0.064τ	0.020τ
No. of Points of χ	1484	250	4000

TABLE 2

It should be noted that the χ function derived from the SIS real I-V curve decays much more rapidly than that χ function corresponding to the SIS ideal I-V curve (16τ compared to 95τ). Fig. 7 illustrates this. The decay rates for the Josephson pair current χ function and the ideal quasiparticle (SIS) χ function may be shown analytically to be the same and the two independent results obtained for M in Table 2 verify this. The much smaller step δt required for the Josephson pair current case compared to that for the SIS calculations is a result of the shorter response time for the Josephson currents. Typically, the Josephson response time is approximately three times smaller than that for the quasiparticle currents. As may be inferred from the "number of points" values in the table, a substantial saving in computer memory is obtained by analyzing mixers containing real SIS junctions rather than ideal SIS junctions.

Having established the digitization constraints on χ , those for the SIS I-V curve automatically follow. $\chi(t)$ is a sine Fourier transform of the I-V curve (minus the ohmic part), from which it follows that the digitization constraints for the I-V curve are:

$$V_{\text{TOTAL}} > 8 V_{\text{gap}} \quad (43)$$

$$\delta V < \frac{V_{\text{gap}}}{30} \quad (44)$$

where: the DC I-V curve is digitized from 0 to V_{TOTAL} volts using an interval of δV ;

$$V_{\text{gap}} = \frac{2\Delta}{e} ; \text{ and}$$

Δ = energy gap value in Joules.

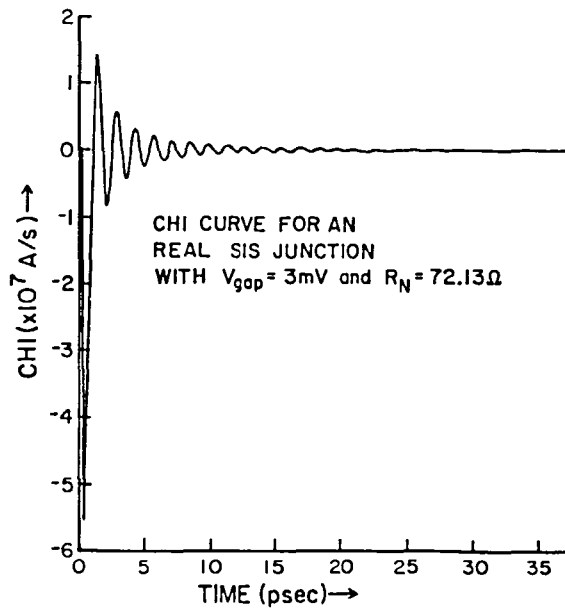
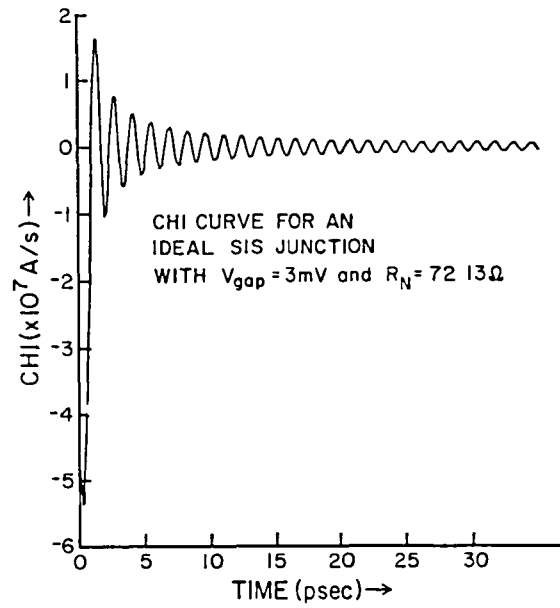


Fig. 7: Comparison Between CHI Function Derived From: (a) An Ideal SIS DC I-V Curve; (b) A Real SIS DC I-V Curve

It should be emphasized that these digitization constraints were obtained from one particular DC I-V curve, albeit a sharp I-V curve. Clearly, different I-V curves will lead to differing digitization constraints. However, on the basis of our experience, the above digitization constraints have ensured sufficient numerical accuracy with all the measured I-V curves we have tested.

The above digitization constraints are embodied into the program GETCHI which is described in Sections 3.1 and 3.2.

3. Description of the Mixer Analysis Program SISCAP and Program GETCHI

Using the theory given in the previous sections, a user oriented computer program was written to analyze the performance of SIS mixers. The programming language used was FORTRAN. The program consists of two parts, SISCAP and GETCHI.

The program GETCHI must be run first, since it provides information on the storage requirements necessary for an accurate analysis in the program SISCAP. Also, GETCHI outputs the discretized I-V curve and the discretized CHI curve in a form suitable for input to the program SISCAP. GETCHI requires the following as inputs: (i) the I-V curve in some arbitrary yet accurate digitized form; (ii) the number of junctions represented in the input DC I-V curve; (iii) the LO frequency; and (iv) the gap voltage of the single equivalent device. Further details on the input/output data structures can be found in Section 3.2.

The program SISCAP requires as inputs the following: (i) the embedding impedances seen by the SIS tunnel junction (excluding the parasitic junction capacitance contribution) at each harmonic of the local oscillator and at the sidebands; (ii) the SIS DC I-V curve (minus the ohmic part, as provided by the program GETCHI); (iii) the SIS χ curve (which is derived from the I-V curve by the program GETCHI, to be described later); (iv) the various operating conditions for the tunnel junction mixer, e.g. DC bias voltage, LO amplitude, the frequencies of the LO, RF and IF; (v) the normal resistance R_N and junction capacitance C_J of the SIS tunnel junction, and finally (vi) the parameters used to control the various numerical calculations within the program.

The output includes (i) the conversion loss, (ii) the RF input impedance; (iii) the IF output impedance, and (iv) the single sideband

mixer noise temperature.

The remainder of this section explains both programs in detail and illustrates the steps used for running them. A complete documented listing of the two programs appears in Appendix A and a general flowchart is given in Fig. 8.

3.1 GETCHI Program Implementation

The main routine of program GETCHI calls various subroutines described below in the sequence indicated.

Subroutine EVEN provides an evenly-spaced (along the voltage axis) internal version of the input I-V data which is used as the reference data for subsequent processing by the program. Linear interpolation is used to calculate these points. If the input data is for an array, subroutine EVEN reduces this to its single junction equivalent. Subroutine EVEN requests as input the number of tunnel junctions arrayed. If not an array, unity should be entered. The given I-V data must be input on device 7.

Subroutine REFINe then takes the I-V internal working data produced by subroutine EVEN and extracts the ohmic or linear portion of the I-V curve.

Subroutine INEXP then interpolates the internal working I-V data stored within the program such that the new spacing and number of points correspond to the correct spacing required for further processing prior to the conversion to CHI data. The LO frequency (FREQ) and the single junction gap voltage (VGAP) are required as input so the program can provide lower limits for the number of LO cycles (NOCYC) and number of points per cycle (NOPNTS). These limits ensure that an accurate

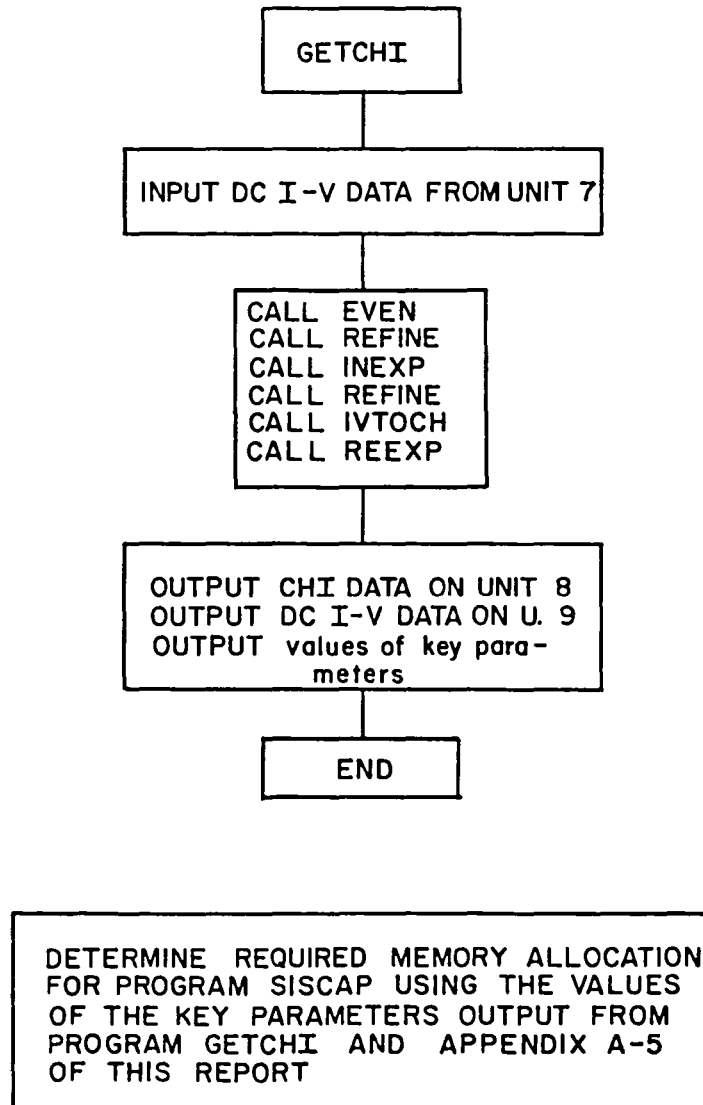


Fig. 8(a): Flowchart of Program GETCHI

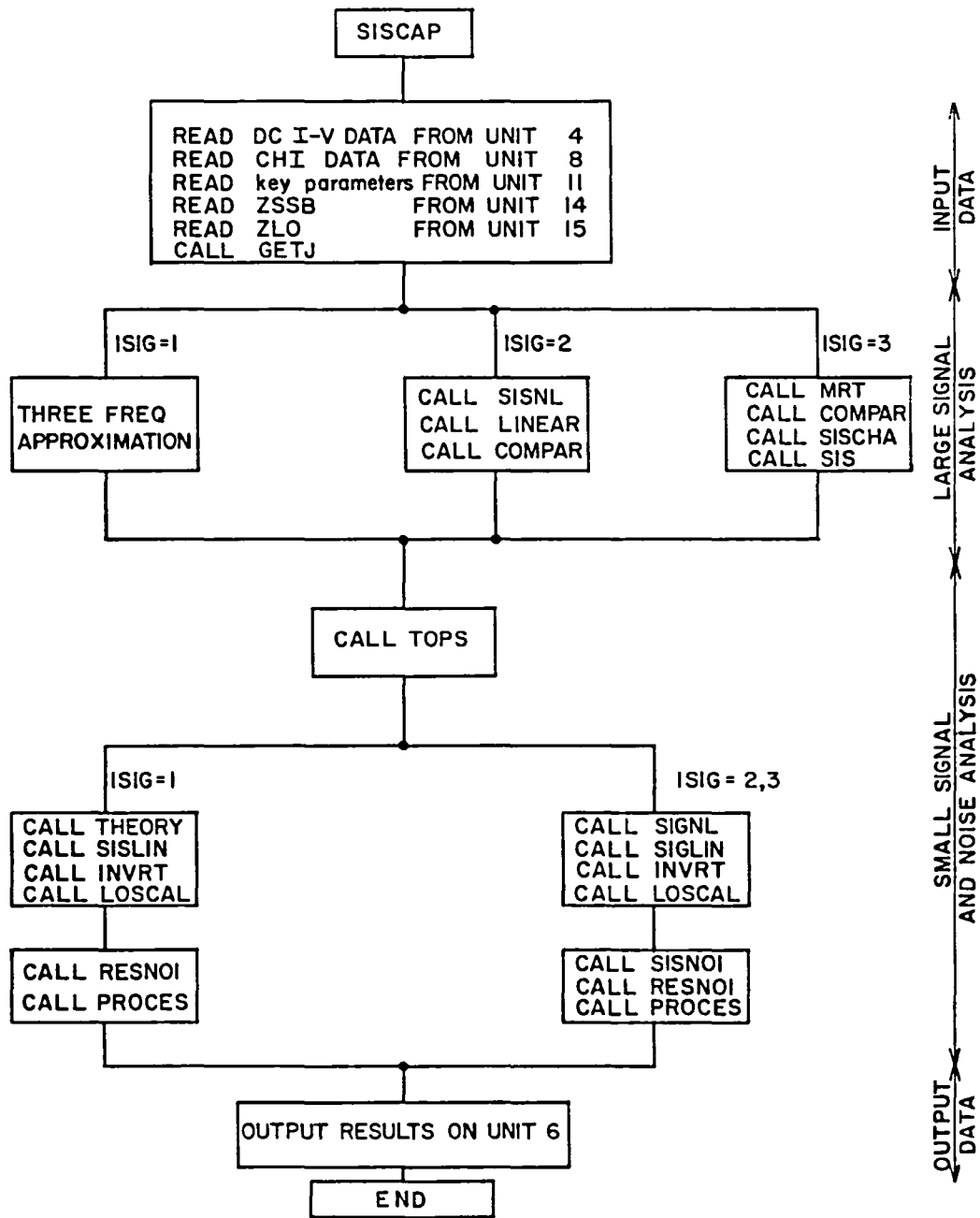


Fig. 8(b): Flowchart of Program SISCAP

calculation is performed in the program SISCAP.

Following this, subroutine REFINE is again called to ensure that the last point of the I-V data is zero current.

Subroutine IVTOCH uses a fast Fourier transform and converts the working I-V data to the equivalent CHI data file for output on device unit number 8.

Finally, subroutine REEXP outputs suitably digitized I-V data for use in evaluating the current I_{DC} and the complex valued parameter J in the SISCAP program. To output this I-V data, the program requests both the number of points required (NOIV) and the spacing between the points (DELTA V). Suggested values for these parameters are NOIV = 1024 and DELTA V = 0.02 mV for a 3mV gap SIS device. For other gap voltage values, DELTA V should be linearly scaled to suit. The DC I-V data is output on device unit number 9.

Output to the console from program GETCHI is a summary of the values of key parameters to be input to program SISCAP. The parameters are: NOCHI, NOIV, NOPNTS and RN. The first three parameters are also used to determine the memory allocation requirement in SISCAP as per Appendix A.5.

3.2 Running the GETCHI Program

A listing of the program GETCHI appears in Appendix A along with the output of a run. The comments in the listing provide a description of the FORTRAN coding.

Prior to running program SISCAP, GETCHI must be run to provide information on memory storage allocation for SISCAP, values of key parameters in program SISCAP as well as to provide the CHI and the DC I-V

curve, each with the appropriate discretization for input to program SISCAP. GETCHI requires as input to it, the DC I-V curve of the SIS junction. Multiple junction I-V curves may be input to GETCHI but the two output files from GETCHI containing CHI and the DC I-V data will reflect those values appropriate to the equivalent single junction device. The program will request the number of junctions (NOJUN) in the series array; a value of unity should be input if a single junction is used.

The number and distribution of the points given in the input DC I-V data file to program GETCHI are at the discretion of the user but must conform to the following guidelines:

- (i) the first I-V data point must be the origin (0.0,0.0);
- (ii) the input I-V points need not be evenly spaced;
- (iii) the span of the input points must be such as to extend well into the linear portion of the I-V curve, i.e. the points must adequately cover the entire nonlinear portion (typically to a voltage four times the gap voltage); and
- (iv) the I-V points must represent a monotonic function.

In order to obtain the CHI function, it is necessary to input the frequency of the local oscillator (FREQ), the gap voltage of the single junction equivalent SIS device (VGAP), the number of points per LO cycle (NOPNTS) to be used in the calculation and the number of cycles of points required to accurately describe CHI (NOCYC) in accordance with the conclusions of section 2.5. The program offers assistance in deciding what the minimum acceptable values for NOPNTS and NOCYC are. Both these numbers must be powers of 2. The parameter, NOCHI, whose value must be known for input to the program SISCAP, is equal to NOPNTS*NOCYC. As such,

the value of NOCHI is always greater than or equal to NOPNTS. The program also outputs the value of RN to be input to the program SISCAP. The program requests both the number of points for output (NOIV) to the file for program SISCAP and the voltage spacing between these points (DELTAV). The number of points (NOIV) must be a power of 2 and 1024 has been found to give satisfactory results. DELTAV, the voltage spacing between the points, is typically 0.02 mV for a 3mV gap device. The DC voltage span covered by these typical parameters is 20.48 mV (= 1024 x 0.02mV) which clearly covers the nonlinear portion of the I-V curve.

3.3 SISCAP Program Implementation

The program commences in the MAIN routine and inputs all the parameters necessary to control the operation of the program. Next, the values of CHI (χ) and the SIS DC I-V characteristic are read in. At this point, control is transferred to the subroutine GETJ in order to obtain the Kramers-Kronig transform of the DC I-V curve and hence the complex function J. Control is then transferred back to the MAIN routine to input the embedding impedances at the local oscillator harmonics (subroutine GETZ) and sideband frequencies (subroutine GETSSB).

All information has now been input and the program is now ready to perform the large signal analysis. There are three methods which may be used:

- (i) the voltage update method for $\omega_p R_N C_J$ products in excess of 0.5;
- (ii) the multiple reflection technique for other $\omega_p R_N C_J$ products; and
- (iii) the three frequency approximate analysis.

The voltage update method proceeds as follows. An estimate of the junction voltage is made. A call is made to subroutine SISNL which

calculates the current flowing into the SIS device, given the input voltage. Next, subroutine LINEAR calculates the voltage required across the embedding network terminals consistent with the current calculated in subroutine SISNL. Finally, COMPAR performs a comparison between the new voltage waveform and the initial estimate of the voltage waveform to determine if a solution has been obtained.

Alternatively, the multiple reflection technique may be used. This proceeds by a call to subroutine MRT which performs the overall iterative algorithm. It in turn calls subroutine SISCHA which sets up various vectors such that the succeeding call to subroutine SIS will solve the nonlinear SIS tunnel junction equations.

If required, a three frequency model calculation can be performed instead of the more general nonlinear analysis routines described above.

Following the completion of the large signal analysis calculations by whatever large signal analysis method, a call to TOPS initiates calculations to obtain the small signal and noise results. TOPS is the principal subprogram controlling the signal and noise analysis programs. It initializes the working matrices to zero and calls SIGNAL and SIGLIN. SIGNAL calculates the matrix conversion elements which are computed from the SIS device parameters together with the large signal analysis waveforms. The embedding impedances at all the relevant sidebands are calculated by subroutine SIGLIN and, by virtue of the linearity, the matrix so calculated is diagonal. The combination of the subroutines SIGLIN and SIGNAL produce the augmented admittance matrix. The combination of the two subroutines INVRT and LOSCAL invert the augmented admittance

matrix and perform the arithmetic to calculate the conversion loss and the output impedance. The noise analysis follows next using calls to SISNOI and RESNOI. SISNOI computes the contribution from the shot noise of the SIS device while the thermal or Johnson noise is computed from subroutine RESNOI. Subroutine PROCES then takes the complete noise matrix and, using the previously calculated impedance conversion matrix, computes the equivalent input noise temperature of the mixer.

If a three frequency analysis is invoked, the small signal and noise analyses are calculated as follows. Subroutine THEORY provides the 3x3 matrix elements describing the small signal conversion and noise correlation process. Subsequent calls to subroutines SIGLIN, INVRT and LOSCAL calculate the conversion loss of the mixer. The single-sideband mixer noise temperature is calculated by calls to subroutines RESNOI and PROCES.

For a more detailed description of the operation of the program, the reader is referred to the comments in the program listing and the general flow chart of Fig. 8.

3.4 Running the Mixer Analysis Program SISCAP

A listing of the SIS mixer analysis program SISCAP appears in Appendix A along with the output of a run. Using the IBM Fortran 77 compiler, the execution time for this particular listing is 0.5 mins on an AMDAHL V6 computer. The comments in the listing provide a description of the FORTRAN coding. To run the program, the following information must be supplied as files accessed via the following FORTRAN unit numbers:

(1) UNIT NO. 15: The embedding network impedances at the LO frequency and the higher harmonics. Preceding the impedance values, there

must be a number indicating the number of impedances in the file. It is read in under I5 format. All impedance values are to be in ohms and are read in as complex variables using format 2E15.8. The program expects there to be NOPNTS/2 impedances in this file. If there are less than this, the program assumes that those impedances given are zero. It is important to note that these impedance values should not include the effect of the parasitic junction capacitance.

(ii) UNIT NO. 14: The sideband impedances in complex form, again in ohms. The ordering of information in this file is as follows: number of impedances in the file, IF impedance, fundamental USB impedance ($Z_e(\omega_1)$), fundamental LSB impedance ($Z_e(\omega_{-1})$), second LO harmonic USB impedance ($Z_e(\omega_2)$) and the second LO harmonic LSB impedance ($Z_e(\omega_{-2})$), etc. Lower sideband impedances should not be input in their complex conjugate form, the program does this operation. As for the previous case, a number indicating the number of impedances in the file must be submitted as the first entry in the data file, using the format I5. The complex impedances are read in under 2E15.8 format. The program expects there to be (NOPNTS - 1) impedances in the files. If there are less than this, the program assumes that those impedances not given are zero. It is important to note that these impedance values should not include the effect of the parasitic junction capacitance.

(iii) UNIT NO. 8: The DC SIS I-V curve is input in the form of the number of points (format I5) in the file followed by the digitized I-V curve (format 2E15.8). The ohmic part, R_N , will have been subtracted out by program GETCHI (See Section 3.2) which should be used to provide the DC I-V curve data.

(iv) UNIT NO. 4: The CHI values for the SIS tunnel junction device

with the following format: the number of points in the file (I5), followed by the values of CHI (2E15.8). The points for this file can be generated by using the program GETCHI (See Section 3.2).

(v) UNIT NO. 11: This file contains all the SIS device parameters together with the various program option values which affect the operating and performance characteristics of program. The parameters and their function are listed sequentially below (all integers are input in the format I5, all real values are input in the format E15.8):

- (a) FREQ: frequency of the local oscillator (LO) in Hertz;
- (b) FIF: intermediate frequency (IF) in Hertz;
- (c) CAP: parasitic junction capacitance of the SIS device in Farads;
- (d) RN: normal resistance of the SIS device in ohms. This value is supplied by the program GETCHI;
- (e) TEMP: operating temperature of the junction in Kelvins;
- (f) IBASE2: binary logarithm of NOIV;
- (g) NOIV: number of points in the I-V data file (this must be a power of 2). The value of NOIV must be the value used in the program GETCHI. Assistance in selecting the value of NOIV is given when program GETCHI is run (See Section 3.2);
- (h) IBASE1: binary logarithm of NOPNTS;
- (i) NOPNTS: number of points into which each LO cycle is subdivided (this must be a power of 2). This value must be obtained from the program GETCHI.
- (j) MMAX: number of sidebands to be considered (e.g. 9 implies 4 upper, 4 lower and the IF sidebands are to be included in the analysis). MMAX must be an odd number. Typically, a value of 15 has been found to give satisfactory results. Its value is always limited to a maximum of

NOPNTS/2 - 1;

(k) NMAX: number of photon points to be considered in the small signal analysis. This establishes the number of terms summed in Eq. 16 to calculate the admittance matrix elements. At typical LO drive levels, at least 6 photon points on each side of the DC bias point are required to ensure reasonable accuracy. Therefore, the minimum for NMAX is $2*6 + 1 = 13$. The maximum value for NMAX is NOPNTS/2 - 1;

(l) ISIG: indicates the type of mixer analysis to be performed: 1 = three port model, 2 = general mixer analysis using voltage update method, 3 = general mixer analysis using multiple reflection technique;

(m) NOPER: maximum number of iterations allowed in the large signal general mixer analysis. This parameter acts as an emergency brake in case the nonlinear analysis does not converge. Typically, its value should be 100. The value of this parameter is irrelevant if the three port approximation is used (ISIG = 1);

(n) NOCHI: number of points required in the CHI (χ) file. The value of this parameter is obtained from the program GETCHI;

(o) NODAT: number of different DC bias voltage cases to be analyzed (see also DELV and VSTART);

(p) TOL: the maximum relative error allowed between successive iterations in the large signal analysis before the solution has converged. Since the computational accuracy of each computer varies from machine to machine, the value assigned to TOL must therefore reflect the respective rounding error of each individual machine. Typically, TOL equal to 0.00001 has been found to be effective on IBM 32 bit machines;

(q) EPS: in a vector of values, EPS is the fraction of the maximum component below which all values are considered to be insignificant and

therefore unduly affected by rounding error and the like. Since the computational accuracy of each computer varies from machine to machine, the value assigned to EPS must therefore reflect the respective rounding error of each individual machine. Typically, EPS equal to 0.00001 has been found to be effective on IBM 32 bit machines;

(r) DELV: increment in DC bias voltage between the different bias cases considered for analysis (in volts). See also NODAT and VSTART;

(s) VSTART: first of the NODAT values of DC bias voltage (in volts). See also NODAT and DELV;

(t) VLOSTR: first of the local oscillator peak voltage values (in volts). See also DELVLO and NLO;

(u) DELVLO: increment in local oscillator peak voltage value (in volts). See also VLOSTR and NLO;

(v) NLO: number of different LO voltage cases to be analyzed. See also VLOSTR and NLO;

(w) P: convergence parameter used in the voltage update large signal analysis; its value lies in the range $0 < P \leq 1$. Typically, its value is unity;

(x) RID: value of the identity resistance (in ohms) to be used in the voltage update large signal analysis method. Typically, R_{ID} set equal to $R_N/2$ has been found to give satisfactory results;

(y) Z₀: value of the characteristic impedance (in ohms) of the transmission line used in the multiple reflection large signal analysis method. Typically, Z_0 set equal to R_N has been found to give satisfactory results.

Output is received from program SISCAP as follows:

(a) UNIT NO. 6: the console output.

3.5 Verification Tests

The program has been verified for the case of large junction capacitance by comparison with the predictions of the three-frequency analysis. In a number of cases (not restricted to a large junction capacitance), the large signal waveforms predicted by this program were found to be consistent with those calculated by an independently developed SIS nonlinear analysis program which was used to study chaos [23]. The mixer temperatures predicted by this program have not been independently verified but do appear reasonable. This project was terminated before the program was extensively employed, and it is possible that errors may occur in various untested parameter ranges.

4. Example

In this section, the mixer analysis program is used to study the effects of parasitic junction capacitance on the performance of an SIS mixer. The experimentally measured I-V curve, shown in Fig. 9, of an SIS element [24] for which $R_N = 72 \Omega$ was assumed to be in a mixer circuit with a 113.9 GHz local oscillator. The intermediate frequency was 1.0 MHz and the IF load resistance was 50Ω . In this low IF limit the signal, image, and LO source impedances must all be equal, and they were chosen to be $55 + i92 \Omega$ (which includes C_J), the value which maximizes the conversion efficiency at a dc voltage in the center of the first photon step in the three-frequency approximation. This SIS mixer was analyzed for a wide range of junction capacitance. In each case the termination impedance at all higher harmonics and sidebands (not including the LO and its sidebands) was the parallel combination of the capacitive reactance and a resistance of 72Ω (arbitrarily chosen equal to R_N).

For each value of capacitance the LO power and the dc voltage were optimized for maximum conversion on the first photon step. Typical junction current and voltage waveforms resulting from the numerical computation in Section A.3 are shown in Fig. 10. The overall results for varying junction capacitances are not plotted, for fear that relatively large interpolation errors may have made them unreliable. The trend of the results is however quite clear.

The largest value of mixer conversion gain, a few dB, was found in the limit of large capacitance, and agreed with the three-frequency approximation. The conversion gain decreased to a minimum of about unity at an $\omega_p R_N C_J$ product of unity, but then increased again for smaller $\omega_p R_N C_J$ values. The mixer noise temperatures corresponding to these results

showed an even less dramatic variation with capacitance, remaining between 20 and 25 K. The mixer output impedance was negative at all capacitance values, while the input impedance was always positive. It must be emphasized that even if these conclusions are verified for this specific mixer circuit, they may be far from typical and should not be taken as general.

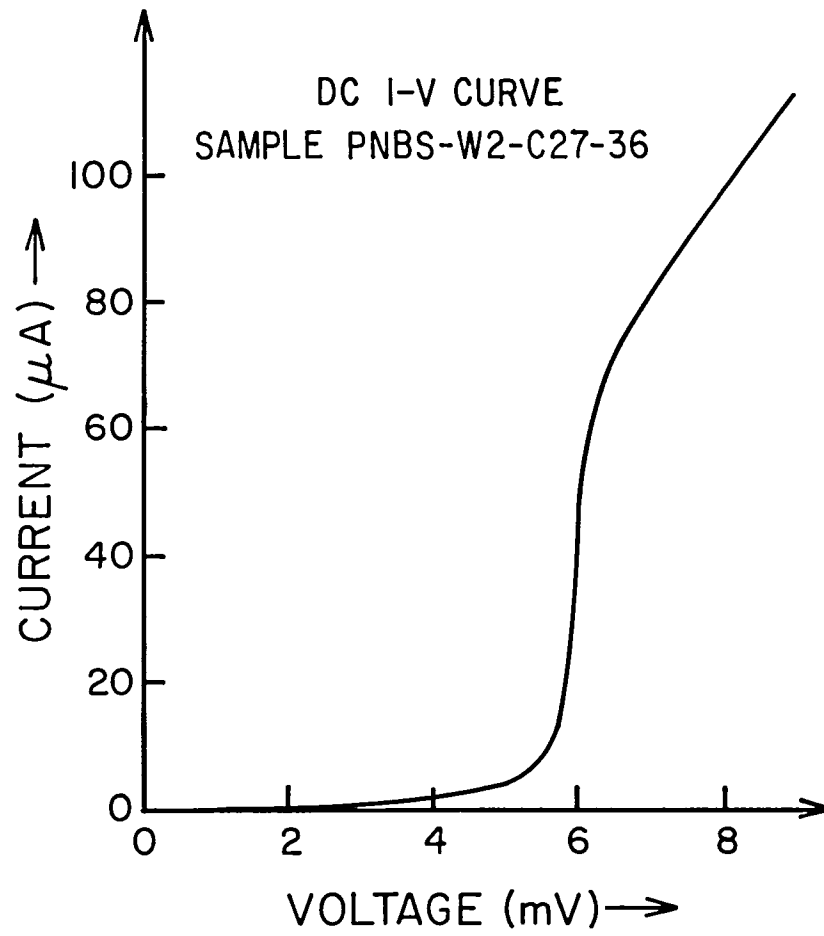


Fig. 9: DC I-V Curve Used in the Example in Section 4

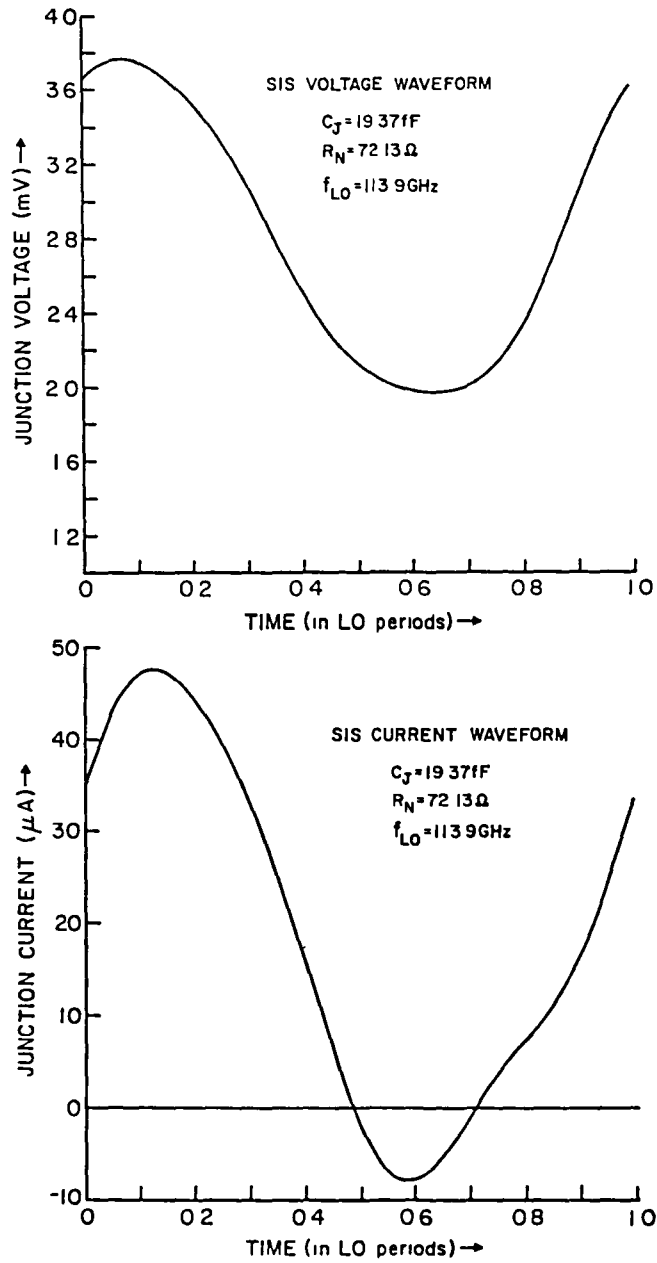


Fig. 10: Typical Junction Waveforms: (a) Voltage; (b) Current

5. Conclusions

A FORTRAN computer program has been developed for analyzing SIS mixers with arbitrary embedding impedances at all LO harmonics and sidebands. This program has been verified using the three-frequency approximation and the multiple reflection algorithm. Typical current and voltage waveforms at the SIS junction are plotted. Although a thorough study of the effect of varying junction capacitance has yet to be completed, in one specific example optimum mixer performance occurs for large or very small values of $\omega_p R_N C_J$. Low values of this parameter, roughly 0.3 to 2.0, lead to a deterioration in mixer performance.

Tests have also been performed on the relative speeds of the two nonlinear large signal analysis methods. For a typical SIS mixer situation, the voltage update method provides an order of magnitude improvement in total CPU time over that required by the multiple reflection technique.

APPENDIX A Supplementary Computer Program Information

A.1 Typical Run of Program SISJUN

The program SISJUN generates, without input, a typical single-junction DC I-V curve in digitized form. It is output on unit 7 and consists of 2049 lines of data. The first few lines of output are shown below. This data is to be used as input to GETCHI and is therefore given as a means for the verification of the correct functioning of programs GETCHI and SISCAP. Although SISJUN generates equally spaced data for input to program GETCHI, this is not a necessity for GETCHI input, as discussed in Section 3.2.

A.2 Typical Run of Program GETCHI

Given in this section is the output of a typical run of the program GETCHI. It should be remembered that three files have to be defined corresponding to FORTRAN unit 7 (input I-V data), unit 8 (output CHI data) and unit 9 (output I-V data). In the example shown here, the program uses as input on unit 7 the output of the program SISJUN.

The listing of the console output (given below) is self explanatory. It should be emphasized that, as a precaution, the two output files of CHI data and DC I-V data should be plotted to ensure there are no discontinuities in this data. Such a situation is possible when the input experimental data has been affected by noise during the measurement process. Such noise can destroy the monotonicity of the output DC I-V curve, a property relied upon by portions of the computer programs described in this report.

FILE: SISJUN DOC A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

sfsjun
 FI 07 DISK SISJUN DAT A1 (PERM RECFM FA LRECL 80
 EXEC FORTXCLG SISJUN XREF GOSTMT MAP

FORTRAN H EXTENDED (ENHANCED)

SOURCE STATEMENTS = 43, PROGRAM SIZE = 1476, SUBPROGRAM NAME = MAIN
 *** Files ' SISJUN TEXT ' and ' SISJUN LISTING ' have been created
 *** Loading ... file ' LOAD MAP A ' is being created
 EXECUTION BEGINS...
 R; T=4.75/5.54 12:15:38

FILE: SISJUN DATA A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

2048

0.0	0.0
0.49999999E-05	0.16666675E-08
0.529999961E-05	0.33333336E-08
0.14999998E-04	0.50000004E-08
0.19999992E-04	0.66666672E-08
0.25000001E-04	0.80000008E-08
0.29999996E-04	0.10000004E-07
0.34999990E-04	0.11666668E-07
0.39999984E-04	0.13333334E-07
0.44999979E-04	0.14999998E-07
0.49999973E-04	0.16666664E-07
0.54999967E-04	0.18333330E-07
0.59999961E-04	0.20000006E-07
0.64999955E-04	0.21666660E-07
0.69999949E-04	0.23333326E-07
0.74999943E-04	0.25000002E-07
0.79999937E-04	0.26666658E-07
0.84999931E-04	0.28333314E-07
0.89999925E-04	0.29999990E-07
0.94999919E-04	0.31666646E-07

FILE: GETCHI DOC A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```
getchi
FI 07 DISK SISJUN DAT A1 ( PERM RECFM FA LRECL 80
FI 08 DISK CHI DAT A1 ( PERM RECFM FA LRECL 80
FI 09 DISK IV DAT A1 ( PERM RECFM FA LRECL 80
EXEC FORTXCLG GETCHI XREF GOSTMT MAP
```

FORTRAN H EXTENDED (ENHANCED)

```
SOURCE STATEMENTS = 31, PROGRAM SIZE = 67042, SUBPROGRAM NAME = MAIN
SOURCE STATEMENTS = 63, PROGRAM SIZE = 2004, SUBPROGRAM NAME = EVEN
SOURCE STATEMENTS = 10, PROGRAM SIZE = 494, SUBPROGRAM NAME =REFINE
SOURCE STATEMENTS = 77, PROGRAM SIZE = 2542, SUBPROGRAM NAME = INEXP
SOURCE STATEMENTS = 56, PROGRAM SIZE = 1578, SUBPROGRAM NAME =IVTOCH
SOURCE STATEMENTS = 71, PROGRAM SIZE = 2210, SUBPROGRAM NAME = FFT
SOURCE STATEMENTS = 15, PROGRAM SIZE = 404, SUBPROGRAM NAME = JUXTA
SOURCE STATEMENTS = 15, PROGRAM SIZE = 484, SUBPROGRAM NAME = FACNO
SOURCE STATEMENTS = 63, PROGRAM SIZE = 1978, SUBPROGRAM NAME = REEXP
*** Files ' GETCHI TEXT ' and ' GETCHI LISTING ' have been created
*** Loading ... file ' LOAD MAP A ' is being created
EXECUTION BEGINS...
```

THIS PROGRAM, GETCHI, PERFORMS A PREPROCESSING FUNCTION ON THE INPUT DC I-V CURVE DATA PRIOR TO USING THE PROGRAM SISCAP. OUTPUT FROM GETCHI IS THE PRE-PROCESSED DC I-V DATA, CHI IN AN APPROPRIATELY DISCRETIZED FORM AND VALUES FOR THE PARAMETERS: NOCHI, NOIV, NOPNTS AND RN

INPUT THE GAP VOLTAGE (VGAP) IN VOLTS OF THE SINGLE JUNCTION EQUIVALENT DEVICE (FORMAT E15.8)
0.003

INPUTTING THE INPUT I-V CURVE DATA FROM UNIT 7

INPUT THE NUMBER OF JUNCTIONS (NOJUN) IN DEVICE (I5)
1

INPUT THE LO FREQUENCY IN HERTZ (FREQ) (E15.8)
113.9e9

NUMBER OF LO CYCLES OF CHI IN SISCAP SHOULD BE > 2
THE NUMBER OF POINTS PER LO CYCLE IN SISCAP SHOULD BE > 99

INPUT NUMBER OF LO CYCLES (NOCYC) (I5)
INPUT NO OF POINTS PER LO CYCLE (NOPNTS) (I5)
4
128

FILE: GETCHI DOC A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

NOCHI = 512

INPUT DELTAV (TYP 0.2000E-04 VOLTS) (E15.8)
INPUT NUMBER OF POINTS REQUIRED (NOIV) (PWR OF 2) (TYP 1024) (I5)
0.00002
1024

INFORMATION FOR TRANSFERRAL TO PROGRAM SISCAP:
OUTPUTTING THE CHI FILE ON UNIT 8: NOCHI = 512
OUTPUTTING THE IV FILE ON UNIT 9: NOIV = 1024
NOPNTS = 128
RN = 0.72131729E+02 OHMS
R; T=13.93/15.93 12:17.46

FILE: CHI DATA A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

512

$\emptyset.\emptyset$ $\emptyset.\emptyset$
 $\emptyset.68591129E-13-\emptyset.23019856E+08$
 $\emptyset.13718226E-12-\emptyset.41334912E+08$
 $\emptyset.20577339E-12-\emptyset.52214416E+08$
 $\emptyset.27436452E-12-\emptyset.55727536E+08$
 $\emptyset.34295564E-12-\emptyset.54098384E+08$
 $\emptyset.41154677E-12-\emptyset.50116304E+08$
 $\emptyset.48013790E-12-\emptyset.45653440E+08$
 $\emptyset.54872903E-12-\emptyset.41148400E+08$
 $\emptyset.61732016E-12-\emptyset.36080416E+08$
 $\emptyset.68591129E-12-\emptyset.29899776E+08$
 $\emptyset.75450242E-12-\emptyset.22654000E+08$
 $\emptyset.82309355E-12-\emptyset.14985496E+08$
 $\emptyset.89166468E-12-\emptyset.76890440E+07$
 $\emptyset.96027526E-12-\emptyset.12803370E+07$
 $\emptyset.10280662E-11 \emptyset.40980000E+07$
 $\emptyset.10974581E-11 \emptyset.84673520E+07$
 $\emptyset.11660490E-11 \emptyset.11769160E+08$
 $\emptyset.12346400E-11 \emptyset.13812084E+08$
 $\emptyset.13032310E-11 \emptyset.14426568E+08$

FILE: IV DATA A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

1024

$\emptyset.\emptyset$ $\emptyset.\emptyset$
 $\emptyset.20000007E-04-\emptyset.27060435E-06$
 $\emptyset.40000014E-04-\emptyset.54120761E-06$
 $\emptyset.60000020E-04-\emptyset.81181088E-06$
 $\emptyset.80000027E-04-\emptyset.10824133E-05$
 $\emptyset.10000003E-03-\emptyset.13530171E-05$
 $\emptyset.12000004E-03-\emptyset.16236208E-05$
 $\emptyset.14000005E-03-\emptyset.18942246E-05$
 $\emptyset.16000005E-03-\emptyset.21648284E-05$
 $\emptyset.18000006E-03-\emptyset.24354322E-05$
 $\emptyset.20000007E-03-\emptyset.27060360E-05$
 $\emptyset.22000007E-03-\emptyset.29766397E-05$
 $\emptyset.24000008E-03-\emptyset.32472444E-05$
 $\emptyset.25999988E-03-\emptyset.35178446E-05$
 $\emptyset.27999980E-03-\emptyset.37884465E-05$
 $\emptyset.29999972E-03-\emptyset.40590494E-05$
 $\emptyset.31999964E-03-\emptyset.43296513E-05$
 $\emptyset.33999956E-03-\emptyset.46002542E-05$
 $\emptyset.35999948E-03-\emptyset.48708571E-05$
 $\emptyset.37999940E-03-\emptyset.51414600E-05$

FILE: SISCAP DOC A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

siscap

FI 11 DISK PARAM DAT A1 (PERM RECFM FA LRECL 80
 FI 04 DISK CHI DAT A1 (PERM RECFM FA LRECL 80
 FI 08 DISK IV DAT A1 (PERM RECFM FA LRECL 80
 FI 14 DISK ZSSB DAT A1 (PERM RECFM FA LRECL 80
 FI 15 DISK ZLO DAT A1 (PERM RECFM FA LRECL 80
 EXEC FORTXCLG SISCAP GOSTMT XREF MAP

FORTRAN H EXTENDED (ENHANCED)

SOURCE STATEMENTS =	170,	PROGRAM SIZE =	42222,	SUBPROGRAM NAME =	MAIN
SOURCE STATEMENTS =	47,	PROGRAM SIZE =	1810,	SUBPROGRAM NAME =	GETSSB
SOURCE STATEMENTS =	39,	PROGRAM SIZE =	1556,	SUBPROGRAM NAME =	GETZ
SOURCE STATEMENTS =	25,	PROGRAM SIZE =	2478,	SUBPROGRAM NAME =	LINEAR
SOURCE STATEMENTS =	68,	PROGRAM SIZE =	20228,	SUBPROGRAM NAME =	SISNL
SOURCE STATEMENTS =	27,	PROGRAM SIZE =	734,	SUBPROGRAM NAME =	COMPAR
SOURCE STATEMENTS =	57,	PROGRAM SIZE =	35034,	SUBPROGRAM NAME =	TOPS
SOURCE STATEMENTS =	26,	PROGRAM SIZE =	1054,	SUBPROGRAM NAME =	RESNOI
SOURCE STATEMENTS =	36,	PROGRAM SIZE =	1754,	SUBPROGRAM NAME =	PROCES
SOURCE STATEMENTS =	79,	PROGRAM SIZE =	4476,	SUBPROGRAM NAME =	SIGNL
SOURCE STATEMENTS =	31,	PROGRAM SIZE =	17608,	SUBPROGRAM NAME =	GETJ
SOURCE STATEMENTS =	16,	PROGRAM SIZE =	762,	SUBPROGRAM NAME =	SIGLIN
SOURCE STATEMENTS =	45,	PROGRAM SIZE =	2430,	SUBPROGRAM NAME =	LOSCAL
SOURCE STATEMENTS =	28,	PROGRAM SIZE =	866,	SUBPROGRAM NAME =	EVALJ
SOURCE STATEMENTS =	40,	PROGRAM SIZE =	1818,	SUBPROGRAM NAME =	SISNOI
SOURCE STATEMENTS =	23,	PROGRAM SIZE =	998,	SUBPROGRAM NAME =	INVRT
SOURCE STATEMENTS =	25,	PROGRAM SIZE =	1238,	SUBPROGRAM NAME =	FACTOR
SOURCE STATEMENTS =	25,	PROGRAM SIZE =	1418,	SUBPROGRAM NAME =	SUBST
SOURCE STATEMENTS =	71,	PROGRAM SIZE =	2210,	SUBPROGRAM NAME =	FFT
SOURCE STATEMENTS =	15,	PROGRAM SIZE =	404,	SUBPROGRAM NAME =	JUXTA
SOURCE STATEMENTS =	15,	PROGRAM SIZE =	484,	SUBPROGRAM NAME =	FACNO
SOURCE STATEMENTS =	15,	PROGRAM SIZE =	576,	SUBPROGRAM NAME =	ZERO
SOURCE STATEMENTS =	140,	PROGRAM SIZE =	4574,	SUBPROGRAM NAME =	THEORY

FILE: SISCAP DOC A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

SOURCE STATEMENTS = 26, PROGRAM SIZE = 962, SUBPROGRAM NAME = DERIJ
 SOURCE STATEMENTS = 66, PROGRAM SIZE = 1600, SUBPROGRAM NAME = BESJ
 SOURCE STATEMENTS = 12, PROGRAM SIZE = 396, SUBPROGRAM NAME = COTH
 SOURCE STATEMENTS = 56, PROGRAM SIZE = 3042, SUBPROGRAM NAME = GEN3PT
 SOURCE STATEMENTS = 65, PROGRAM SIZE = 1754, SUBPROGRAM NAME = TERP5
 SOURCE STATEMENTS = 65, PROGRAM SIZE = 6928, SUBPROGRAM NAME = MRT
 SOURCE STATEMENTS = 20, PROGRAM SIZE = 12252, SUBPROGRAM NAME = SISCHA
 SOURCE STATEMENTS = 110, PROGRAM SIZE = 4450, SUBPROGRAM NAME = SIS
 SOURCE STATEMENTS = 12, PROGRAM SIZE = 430, SUBPROGRAM NAME = YFUNCT
 SOURCE STATEMENTS = 38, PROGRAM SIZE = 854, SUBPROGRAM NAME = COMP2
 SOURCE STATEMENTS = 8, PROGRAM SIZE = 388, SUBPROGRAM NAME = FIXPHA
 *** Files ' SISCAP TEXT ' and ' SISCAP LISTING ' have been created
 *** Loading ... file ' LOAD MAP A ' is being created
 EXECUTION BEGINS...

FREQ = 0.11390000E+12HZ FIF = 0.10000000E+07HZ
 CAP = 0.19371999E-13F RN = 0.72131729E+02OHMS
 TEMP = 0.26999998E+01K
 IBASE2 = 10 NOIV = 1024
 IBASE1 = 7 NOPNTS = 128
 MMAX = 31 NMAX = 31
 ISIG = 2 NOPER = 50
 NOCHI = 512 NODAT = 1
 TOL = 0.10000000E-03 EPS = 0.10000000E-03
 DELV = 0.25000001E-04VOLTS VSTART = 0.27999999E-02VOLTS
 VLOSTR = 0.35000001E-02VOLTS DELVLO = 0.10000000E-03VOLTS
 NLO = 1 P = 0.10000000E+01
 RID = 0.50000000E+02OHMS Z0 = 0.50000000E+02OHMS

INPUTTING THE CHI FUNCTION
 DELTAT = 0.68597905E-13 SECS
 NUMBER OF POINTS READ = 512

INPUTTING THE SIS IV CHARACTERISTIC
 DELTAV = 0.19997358E-04 VOLTS
 NUMBER OF POINTS READ = 1024

CALCULATING THE VECTOR J

INPUTTING THE LO HARMONIC IMPEDANCES
 THE FIRST 10 LO HARM IMPEDANCES (EXC CAPAC) ARE:
 0 0.0 +J 0.0 OHMS
 1 0.55000000E+02+J 0.92000000E+02OHMS
 2 0.72130005E+02+J 0.99999994E-10OHMS

FILE: SISCAP DOC A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

3 0.72130005E+02+J 0.99999994E-100HMS
 4 0.72130005E+02+J 0.99999994E-100HMS
 5 0.72130005E+02+J 0.99999994E-100HMS
 6 0.72130005E+02+J 0.99999994E-100HMS
 7 0.72130005E+02+J 0.99999994E-100HMS
 8 0.72130005E+02+J 0.99999994E-100HMS
 9 0.72130005E+02+J 0.99999994E-100HMS
 Y PUMP (INCL CAPAC) = 0.47871843E-02 +J -0.80076605E-02S
 NUMBER OF POINTS READ = 64

INPUTTING SIDEBAND TERMINATION INFORMATION
 THE FIRST 10 SIDEBAND IMPEDANCES (EXC CAPAC):

0 0.50000000E+02+J 0.0 OHMS
 1 0.55000000E+02+J 0.92000000E+020HMS
 -1 0.55000000E+02+J 0.92000000E+020HMS
 2 0.72130005E+02+J 0.99999994E-100HMS
 -2 0.72130005E+02+J 0.99999994E-100HMS
 3 0.72130005E+02+J 0.99999994E-100HMS
 -3 0.72130005E+02+J 0.99999994E-100HMS
 4 0.72130005E+02+J 0.99999994E-100HMS
 -4 0.72130005E+02+J 0.99999994E-100HMS
 5 0.72130005E+02+J 0.99999994E-100HMS
 Y SIGNAL (INCL CAPAC) = 0.47871843E-02 +J -0.80076605E-02S
 Y IMAGE (INCL CAPAC) = 0.47871843E-02 +J 0.80076605E-02S
 NUMBER OF POINTS READ = 127

 *****CASE 1*****

EMBEDDING THEVENIN VDC SOURCE = 0.27999997E-02 VOLTS
 EMBEDDING THEVENIN VLO SOURCE (PEAK) = 0.34999999E-02 VOLTS

INCIDENT LOCAL OSCILLATOR POWER = 0.27840887E-07 WATTS

GENERAL NONLINEAR ANALYSIS USING VOLTAGE UPDATE METHOD
 BEGINNING THE ITERATION PHASE

ITERATION NUMBER = 1
 ERR = 0.10000000E+01 POSN NO = 1

 ITERATION NUMBER = 2
 ERR = 0.13908285E+00 POSN NO = 74

 ITERATION NUMBER = 3
 ERR = 0.78462720E-01 POSN NO = 85

 ITERATION NUMBER = 4
 ERR = 0.59753280E-01 POSN NO = 92

 ITERATION NUMBER = 5
 ERR = 0.16621690E-01 POSN NO = 99

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ITERATION NUMBER = 6
ERR = 0.53864606E-02 POSN NO = 85

ITERATION NUMBER = 7
ERR = 0.31008909E-02 POSN NO = 93

ITERATION NUMBER = 8
ERR = 0.98307454E-03 POSN NO = 97

ITERATION NUMBER = 9
ERR = 0.38796710E-03 POSN NO = 93

ITERATION NUMBER = 10
ERR = 0.18293827E-03 POSN NO = 94

ITERATION NUMBER = 11
ERR = 0.61962215E-04 POSN NO = 95

LARGE SIGNAL ANALYSIS COMPLETED IN 11 ITNS

POINT NO. =	1VOLTAGE =	0.36563654E-02	CURRENT =	0.35102436E-04
POINT NO. =	2VOLTAGE =	0.36812625E-02	CURRENT =	0.36557831E-04
POINT NO. =	3VOLTAGE =	0.37026438E-02	CURRENT =	0.37954203E-04
POINT NO. =	4VOLTAGE =	0.37205843E-02	CURRENT =	0.39285034E-04
POINT NO. =	5VOLTAGE =	0.37351914E-02	CURRENT =	0.40532206E-04
POINT NO. =	6VOLTAGE =	0.37465971E-02	CURRENT =	0.41695879E-04
POINT NO. =	7VOLTAGE =	0.37549580E-02	CURRENT =	0.42753862E-04
POINT NO. =	8VOLTAGE =	0.37604398E-02	CURRENT =	0.43715656E-04
POINT NO. =	9VOLTAGE =	0.37632226E-02	CURRENT =	0.44562665E-04
POINT NO. =	10VOLTAGE =	0.37634813E-02	CURRENT =	0.45304492E-04
POINT NO. =	11VOLTAGE =	0.37613946E-02	CURRENT =	0.45932538E-04
POINT NO. =	12VOLTAGE =	0.37571308E-02	CURRENT =	0.46451751E-04
POINT NO. =	13VOLTAGE =	0.37508472E-02	CURRENT =	0.46863002E-04
POINT NO. =	14VOLTAGE =	0.37426832E-02	CURRENT =	0.47166192E-04
POINT NO. =	15VOLTAGE =	0.37327681E-02	CURRENT =	0.47370107E-04
POINT NO. =	16VOLTAGE =	0.37212060E-02	CURRENT =	0.47475507E-04
POINT NO. =	17VOLTAGE =	0.37080892E-02	CURRENT =	0.47486261E-04
POINT NO. =	18VOLTAGE =	0.36934826E-02	CURRENT =	0.47415029E-04
POINT NO. =	19VOLTAGE =	0.36774450E-02	CURRENT =	0.47258392E-04
POINT NO. =	20VOLTAGE =	0.36600123E-02	CURRENT =	0.47026100E-04
POINT NO. =	21VOLTAGE =	0.36412100E-02	CURRENT =	0.46722096E-04
POINT NO. =	22VOLTAGE =	0.36210504E-02	CURRENT =	0.46355111E-04
POINT NO. =	23VOLTAGE =	0.35995406E-02	CURRENT =	0.45924549E-04
POINT NO. =	24VOLTAGE =	0.35766761E-02	CURRENT =	0.45438268E-04
POINT NO. =	25VOLTAGE =	0.35524534E-02	CURRENT =	0.44896689E-04
POINT NO. =	26VOLTAGE =	0.35268620E-02	CURRENT =	0.44308676E-04
POINT NO. =	27VOLTAGE =	0.34998977E-02	CURRENT =	0.43670356E-04
POINT NO. =	28VOLTAGE =	0.34715536E-02	CURRENT =	0.42993066E-04
POINT NO. =	29VOLTAGE =	0.34418299E-02	CURRENT =	0.42271175E-04
POINT NO. =	30VOLTAGE =	0.34107291E-02	CURRENT =	0.41509833E-04
POINT NO. =	31VOLTAGE =	0.33782658E-02	CURRENT =	0.40709172E-04
POINT NO. =	32VOLTAGE =	0.33444576E-02	CURRENT =	0.39871244E-04
POINT NO. =	33VOLTAGE =	0.33093365E-02	CURRENT =	0.38996906E-04
POINT NO. =	34VOLTAGE =	0.32729360E-02	CURRENT =	0.38083905E-04
POINT NO. =	35VOLTAGE =	0.32353105E-02	CURRENT =	0.37137594E-04

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POINT NO. = 36VOLTAGE = 0.31965207E-02CURRENT = 0.36154655E-04
 POINT NO. = 37VOLTAGE = 0.31566401E-02CURRENT = 0.35135294E-04
 POINT NO. = 38VOLTAGE = 0.31157513E-02CURRENT = 0.34081284E-04
 POINT NO. = 39VOLTAGE = 0.30739547E-02CURRENT = 0.32992626E-04
 POINT NO. = 40VOLTAGE = 0.30313574E-02CURRENT = 0.31867166E-04
 POINT NO. = 41VOLTAGE = 0.29880819E-02CURRENT = 0.30705502E-04
 POINT NO. = 42VOLTAGE = 0.29442557E-02CURRENT = 0.29508359E-04
 POINT NO. = 43VOLTAGE = 0.29000205E-02CURRENT = 0.28276278E-04
 POINT NO. = 44VOLTAGE = 0.28555247E-02CURRENT = 0.27009199E-04
 POINT NO. = 45VOLTAGE = 0.28109262E-02CURRENT = 0.25706700E-04
 POINT NO. = 46VOLTAGE = 0.27663852E-02CURRENT = 0.24371766E-04
 POINT NO. = 47VOLTAGE = 0.27220668E-02CURRENT = 0.23002400E-04
 POINT NO. = 48VOLTAGE = 0.26781391E-02CURRENT = 0.21606917E-04
 POINT NO. = 49VOLTAGE = 0.26347695E-02CURRENT = 0.20178020E-04
 POINT NO. = 50VOLTAGE = 0.25921215E-02CURRENT = 0.18730527E-04
 POINT NO. = 51VOLTAGE = 0.25503556E-02CURRENT = 0.17256368E-04
 POINT NO. = 52VOLTAGE = 0.25096249E-02CURRENT = 0.15773418E-04
 POINT NO. = 53VOLTAGE = 0.24700745E-02CURRENT = 0.14274468E-04
 POINT NO. = 54VOLTAGE = 0.24318350E-02CURRENT = 0.12772449E-04
 POINT NO. = 55VOLTAGE = 0.23950271E-02CURRENT = 0.11269207E-04
 POINT NO. = 56VOLTAGE = 0.23597558E-02CURRENT = 0.97750744E-05
 POINT NO. = 57VOLTAGE = 0.23261076E-02CURRENT = 0.82930055E-05
 POINT NO. = 58VOLTAGE = 0.22941544E-02CURRENT = 0.68375812E-05
 POINT NO. = 59VOLTAGE = 0.22639451E-02CURRENT = 0.54113771E-05
 POINT NO. = 60VOLTAGE = 0.22355143E-02CURRENT = 0.40259911E-05
 POINT NO. = 61VOLTAGE = 0.22088757E-02CURRENT = 0.26851048E-05
 POINT NO. = 62VOLTAGE = 0.21840241E-02CURRENT = 0.14031393E-05
 POINT NO. = 63VOLTAGE = 0.21609364E-02CURRENT = 0.18249557E-06
 POINT NO. = 64VOLTAGE = 0.21395762E-02CURRENT = -0.96604344E-06
 POINT NO. = 65VOLTAGE = 0.21198681E-02CURRENT = -0.20427105E-05
 POINT NO. = 66VOLTAGE = 0.21018125E-02CURRENT = -0.30309020E-05
 POINT NO. = 67VOLTAGE = 0.20852718E-02CURRENT = -0.39313018E-05
 POINT NO. = 68VOLTAGE = 0.20701862E-02CURRENT = -0.47391368E-05
 POINT NO. = 69VOLTAGE = 0.20564718E-02CURRENT = -0.54530101E-05
 POINT NO. = 70VOLTAGE = 0.20440421E-02CURRENT = -0.60664897E-05
 POINT NO. = 71VOLTAGE = 0.20328118E-02CURRENT = -0.65796959E-05
 POINT NO. = 72VOLTAGE = 0.20227018E-02CURRENT = -0.69922826E-05
 POINT NO. = 73VOLTAGE = 0.20136358E-02CURRENT = -0.73088158E-05
 POINT NO. = 74VOLTAGE = 0.20055503E-02CURRENT = -0.75217104E-05
 POINT NO. = 75VOLTAGE = 0.19983689E-02CURRENT = -0.76426259E-05
 POINT NO. = 76VOLTAGE = 0.19921069E-02CURRENT = -0.76624419E-05
 POINT NO. = 77VOLTAGE = 0.19866740E-02CURRENT = -0.75993303E-05
 POINT NO. = 78VOLTAGE = 0.19820742E-02CURRENT = -0.74446871E-05
 POINT NO. = 79VOLTAGE = 0.19783031E-02CURRENT = -0.72172115E-05
 POINT NO. = 80VOLTAGE = 0.19753748E-02CURRENT = -0.69029047E-05
 POINT NO. = 81VOLTAGE = 0.19733123E-02CURRENT = -0.65317727E-05
 POINT NO. = 82VOLTAGE = 0.19721638E-02CURRENT = -0.60873426E-05
 POINT NO. = 83VOLTAGE = 0.19719815E-02CURRENT = -0.55932760E-05
 POINT NO. = 84VOLTAGE = 0.19728362E-02CURRENT = -0.50428062E-05
 POINT NO. = 85VOLTAGE = 0.19748122E-02CURRENT = -0.44538319E-05
 POINT NO. = 86VOLTAGE = 0.19780074E-02CURRENT = -0.38258440E-05
 POINT NO. = 87VOLTAGE = 0.19825266E-02CURRENT = -0.31720265E-05
 POINT NO. = 88VOLTAGE = 0.19884899E-02CURRENT = -0.24886249E-05
 POINT NO. = 89VOLTAGE = 0.19960220E-02CURRENT = -0.18043793E-05
 POINT NO. = 90VOLTAGE = 0.20052569E-02CURRENT = -0.10990625E-05
 POINT NO. = 91VOLTAGE = 0.20163292E-02CURRENT = -0.39467704E-06
 POINT NO. = 92VOLTAGE = 0.20293787E-02CURRENT = 0.31491800E-06
 POINT NO. = 93VOLTAGE = 0.20445397E-02CURRENT = 0.10105286E-05
 POINT NO. = 94VOLTAGE = 0.20619468E-02CURRENT = 0.16979029E-05
 POINT NO. = 95VOLTAGE = 0.20817227E-02CURRENT = 0.23706962E-05
 POINT NO. = 96VOLTAGE = 0.21039834E-02CURRENT = 0.30339870E-05
 POINT NO. = 97VOLTAGE = 0.21288260E-02CURRENT = 0.36715355E-05
 POINT NO. = 98VOLTAGE = 0.21563403E-02CURRENT = 0.42979227E-05
 POINT NO. = 99VOLTAGE = 0.21865845E-02CURRENT = 0.49086666E-05
 POINT NO. = 100VOLTAGE = 0.22196025E-02CURRENT = 0.54999255E-05
 POINT NO. = 101VOLTAGE = 0.22554081E-02CURRENT = 0.60887687E-05
 POINT NO. = 102VOLTAGE = 0.22939951E-02CURRENT = 0.66628563E-05

POINT NO. = 103VOLTAGE = 0.23353205E-02CURRENT = 0.72361436E-05
 POINT NO. = 104VOLTAGE = 0.23793189E-02CURRENT = 0.78079611E-05
 POINT NO. = 105VOLTAGE = 0.24258881E-02CURRENT = 0.83870545E-05
 POINT NO. = 106VOLTAGE = 0.24749034E-02CURRENT = 0.89761743E-05
 POINT NO. = 107VOLTAGE = 0.25262027E-02CURRENT = 0.95865689E-05
 POINT NO. = 108VOLTAGE = 0.25795978E-02CURRENT = 0.10218384E-04
 POINT NO. = 109VOLTAGE = 0.26348669E-02CURRENT = 0.10884571E-04
 POINT NO. = 110VOLTAGE = 0.26917665E-02CURRENT = 0.11585973E-04
 POINT NO. = 111VOLTAGE = 0.27500226E-02CURRENT = 0.12333083E-04
 POINT NO. = 112VOLTAGE = 0.28093394E-02CURRENT = 0.13129320E-04
 POINT NO. = 113VOLTAGE = 0.28693988E-02CURRENT = 0.13978235E-04
 POINT NO. = 114VOLTAGE = 0.29298668E-02CURRENT = 0.14888705E-04
 POINT NO. = 115VOLTAGE = 0.29903932E-02CURRENT = 0.15862803E-04
 POINT NO. = 116VOLTAGE = 0.30506190E-02CURRENT = 0.16903679E-04
 POINT NO. = 117VOLTAGE = 0.31101780E-02CURRENT = 0.18010862E-04
 POINT NO. = 118VOLTAGE = 0.31687077E-02CURRENT = 0.19187792E-04
 POINT NO. = 119VOLTAGE = 0.32258469E-02CURRENT = 0.20430685E-04
 POINT NO. = 120VOLTAGE = 0.32812464E-02CURRENT = 0.21738233E-04
 POINT NO. = 121VOLTAGE = 0.33345749E-02CURRENT = 0.23103901E-04
 POINT NO. = 122VOLTAGE = 0.33855219E-02CURRENT = 0.24523295E-04
 POINT NO. = 123VOLTAGE = 0.34338073E-02CURRENT = 0.25988586E-04
 POINT NO. = 124VOLTAGE = 0.34791802E-02CURRENT = 0.27487957E-04
 POINT NO. = 125VOLTAGE = 0.35214273E-02CURRENT = 0.29013652E-04
 POINT NO. = 126VOLTAGE = 0.35603768E-02CURRENT = 0.30549549E-04
 POINT NO. = 127VOLTAGE = 0.35959005E-02CURRENT = 0.32087453E-04
 POINT NO. = 128VOLTAGE = 0.36279093E-02CURRENT = 0.33610151E-04
 DC VOLTAGE AT THE JUNCTION = 0.27999971E-02 VOLTS
 LO VOLTAGE (PEAK) AT THE JUNCTION = 0.92197349E-03 VOLTS

SMALL SIGNAL AND NOISE ANALYSIS SECTION

DETERMINING SMALL SIGNAL MIXER PROPERTIES USING THE GENERAL ANALYSIS

IF OUTPUT IMPEDANCE = 0.54818091E+03 +J -0.23796079E-02
 IF VSWR REFERRED TO 50.00 OHMS = 0.10963613E+02
 OUTPUT MISMATCH GAIN = 0.30640012E+00 (-0.51371098E+01DB)

INPUT SIGNAL IMPEDANCE = 0.85262650E+02 +J 0.93624878E+01OHMS
 INPUT MISMATCH GAIN = 0.82252783E+00 (-0.84849358E+00DB)
 INPUT GAIN CALCULATION REFERRED TO = 0.20889105E+03 OHMS

CONVERSION GAIN (USB) EQUALS -0.30229321E+01 DB
 CONVERSION GAIN (LSB) EQUALS -0.30229263E+01 DB

SSB TEMP OF MIXER (USB) = 0.23333755E+02 DEG K
 SSB TEMP OF MIXER (LSB) = 0.23333710E+02 DEG K

R; T=244.59/252.26 14:03:14

FILE: PARAM DAT A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

2	ISWIT
1	NODAT
0.025E-3	DELV
2.8000E-3	VSTART
3.5000E-3	VLOSTR
0.1000E-3	DELVLO
1	NLO
1.0E-4	TOL
1.0E-4	EPS
128	NOPNTS
7	IBASE1
1024	NOIV
10	IBASE2
512	NCCHI
50	NCPER
31	M:AX
31	NMAX
72.131729	RN
19.3720E-15	CAP
2.7	TEMP
113.9E9	FREQ
1.0E6	FIF
1.0	P
50.000	RID
50.0	ZF

A.3 Typical Run of Program SISCAP

The following pages show a typical run of program SISCAP. It utilizes the CHI and DC I-V data produced from the run of GETCHI shown in the previous section. This program uses as input the following files: CHI data (unit no. 4), processed DC I-V data (unit no. 8), control parameters (unit no. 11), sideband termination impedances (unit no. 14) and LO harmonic impedances (unit no. 15). One output file is generated via the console.

A.4 Memory Allocation Requirements of GETCHI

Memory is allocated in program GETCHI in accordance with the following rules. NUM is preset by subroutine EVEN to be 4096. NOCHI and NOIV are numbers which the user obtains by running program GETCHI. Since the user needs the value of these parameters prior to running the program (in order to allocate the correct amount of memory for the program), the program may have to be run twice, the first time with an excessive amount of memory in order to obtain the values of NOCHI and NOIV. Table 2 below indicates the correct memory allocation required and in which subroutine the memory space has to be declared.

VARIABLE	SUBROUTINE	SIZE
VOLT2	MAIN	NUM
CUR2	MAIN	NUM
VOLT3	MAIN	NOCHI
CUR3	MAIN	NOCHI
VOLT4	MAIN	NOIV
CUR4	MAIN	NOIV

TABLE 2

VARIABLE	SUBROUTINE	SIZE
TIME	MAIN	NOCHI
CHI	MAIN	NOCHI
CCHI	MAIN	2*NOCHI
FACTOR	MAIN	2*NOCHI

TABLE 2

A.5 Memory Allocation Requirements of SISCAP

This section outlines the memory allocation requirements of program SISCAP. There are 5 key parameter values which must be specified prior to allocating the appropriate memory, namely NOPNTS, NOIV, NOCHI, MMAX and NMAX.

NOPNTS and NOCHI are determined by the discretization constraints on CHI. NOPNTS is the number of points per LO cycle and NOCHI is the number of CHI points input to SISCAP. Both are provided by using the program GETCHI. NOPNTS must be a power of 2 and NOCHI, in addition to being a power of 2, must be equal to or greater than NOPNTS.

NOIV is the number of points in the I-V curve input to the program SISCAP. It must also be a power of 2 and must be large enough such that the discretization of the I-V curve is adequate. This value is obtained from program GETCHI.

MMAX indicates the number of LO sidebands which are taken into account. MMAX must be odd and is limited to $\text{NOPNTS}/2 - 1$ in value. See Section 3.4 item (j) for a more detailed discussion.

NMAX (assumed odd) indicates how many terms are significant in the series which are used to calculate the small signal conversion properties of the mixer. Its value should be as discussed in item (k) of Section 3.4.

Having established these values, the memory allocation is as per Table 4. Note that the symbol '*' indicates a multiplication whereas the symbol 'x' indicates a multidimensional array.

VARIABLE	SUBROUTINE	SIZE
ZIMPED	MAIN	NOPNTS/2
VSOURC	MAIN	NOPNTS/2
CVAL	MAIN	NOPNTS
VOLT	MAIN	NOPNTS
CUR	MAIN	NOPNTS
OLDVOL	MAIN	NOPNTS
CTEMP	LINEAR	NOPNTS
W	TOPS	NOPNTS
CVOL	SIGNL	NOPNTS
CVOL	SISNL	NOPNTS
FACTOR	MAIN	2*MAX OF (NOIV & NOCHI)
J	MAIN	NOIV
IVDAT	MAIN	NOIV
CCHI	SISNL	NOCHI*2
CTEMP	GETJ	NOIV*2

TABLE 4

VARIABLE	SUBROUTINE	SIZE
ZSSB	MAIN	NOPNTS-1
CHI	MAIN	NOCHI
UTERM	SISNL	NOCHI*2
YSIG	TOPS	MMAx x MMAx
NOISE	TOPS	MMAx x MMAx
ZSIG	TOPS	MMAx x MMAx
B	TOPS	MMAx
STORE	TOPS	MMAx x MMAx
STORE	PROCES	MMAx
YSI2	TOPS	3 x 3
NOI2	TOPS	3 x 3
ZSI2	TOPS	3 x 3
VAL	THEORY	NMAx+10
STORE	TERP5	4
ESOURC	MRT	NOPNTS
ELEFT	MRT	NOPNTS
ERIGHT	MRT	NOPNTS
RHO	MRT	NOPNTS
CCUR	SISCHA	NOPNTS
ZTERM	SISCHA	NOPNTS
PHASE	SISCHA	NOCHI
VOLT2	SISCHA	NOCHI
UTERM	SISCHA	NOCHI
CVOL	SISNL	NOPNTS

TABLE 4 CONT.

A.6 Listing of Program SISJUN

This section gives the listing of the test data program SISJUN.

FILE: SISJUN FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

C
C THIS PROGRAM PROVIDES A STANDARD TEST DC I-V CURVE
C IN WHICH TO VERIFY THE CORRECT FUNCTIONING OF THE
C PROGRAMS GETCHI AND SISCAP
C
C I-V CURVE FOR FUNCTION PNBS W2 C2736 D4
C
C V1 = 0.0
C V2 = 2.44
C V3 = 5.99
C V4 = 9.20
C
C NOPNTS = 2048
C DELTAV = 0.01
C
C WRITE(7,19) NOPNTS
19 FORMAT(I5)
C
C VSPAN = FLOAT(NOPNTS-1) * DELTAV
C
C I1 = 1
C I2M1 = V2 / DELTAV + 0.5
C I2 = I2M1 + 1
C I3M1 = V3 / DELTAV + 0.5
C I3 = I3M1 + 1
C I4M1 = V4 / DELTAV + 0.5
C I4 = I4M1 + 1
C
C DO 100 I = I1, I2M1
C VOUT = (FLOAT(I-1) * DELTAV)
C CUROUT = (VOUT/3.0) * 1.0E-6 / 2.0
C VOUT = VOUT * 1.0E-3 / 2.0
C WRITE(7,110) VOUT, CUROUT
110 FORMAT(2E15.8)
100 CONTINUE
C
C DO 200 I = I2, I3M1
C VOUT = (FLOAT(I-1) * DELTAV)
C CUROUT = (0.9*VOUT - 1.37 + EXP((VOUT-4.98)*3.0775) +
1 EXP((VOUT-5.749)*12.61)) * 1.0E-6 / 2.0
C VOUT = VOUT * 1.0E-3 / 2.0
C WRITE(7,110) VOUT, CUROUT
200 CONTINUE
C
C DO 300 I = I3, I4M1
C VOUT = (FLOAT(I-1) * DELTAV)
C CUROUT = (15.4325*VOUT - 25.33 - EXP((7.086-VOUT)*2.0125) -
1 EXP((6.27-VOUT)*8.45)) * 1.0E-6 / 2.0
C VOUT = VOUT * 1.0E-3 / 2.0
C WRITE(7,110) VOUT, CUROUT
300 CONTINUE
C
C DO 400 I = I4, NOPNTS
C VOUT = (FLOAT(I-1)*DELTAV)
C CUROUT = (14.1637*VOUT - 125.78/VOUT) * 1.0E-6 / 2.0
C VOUT = VOUT * 1.0E-3 / 2.0
C WRITE(7,110) VOUT, CUROUT
400 CONTINUE
C
C STOP
C END

```

A.7 Listing of Program GETCHI

This section gives the listing of the preprocessing program GETCHI.

FILE: GETCHI FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

REAL VOLT2(4096), VOLT3(512), VOLT4(1024)          GET00010
REAL CUR2(4096), CUR3(512), CUR4(1024)            GET00020
REAL TIME(512), CHI(512)                          GET00030
COMPLEX CCHI(1024), FACTOR(1024)                  GET00040
COMMON /GAPINF/ VGAP                              GET00050
C                                                    GET00060
C SUBROUTINE GETCHI PRODUCES THE CHI FUNCTION WITH THE GET00070
C APPROPRIATE SPECIFIED DISCRETIZATION. THIS PROGRAM GET00080
C REQUIRES AS INPUT THE I-V CURVE OF THE SIS JUNCTION. GET00090
C OUTPUT IS TWO-FOLD:                               GET00100
C (I) THE TABULATED CHI FUNCTION (UNIT 8), AND      GET00110
C (II) A COMPATIBLE TABULATED DISCRETIZATION OF THE GET00120
C I-V DATA (UNIT 9).                               GET00130
C                                                    GET00140
C THE INPUT I-V DATA WILL BE CHECKED FOR THE FOLLOWING REQUIREMENTS: GET00150
C (A) THE FIRST DATA POINT MUST BE THE ORIGIN;    GET00160
C (B) THE I-V FUNCTION MUST BE MONOTONIC;         GET00170
C (C) THE RANGE OF INPUT DATA MUST BE SUCH THAT THE VOLTAGE GET00180
C RANGE EXTENDS FROM ZERO TO VOLTAGES WELL INTO THE LINEAR GET00190
C RANGE. THE INPUT DATA DOES NOT HAVE TO BE EVENLY DISCRETIZED. GET00200
C                                                    GET00210
C WRITE(6,2000)                                     GET00220
2000 FORMAT(/1X,'THIS PROGRAM, GETCHI, PERFORMS A PREPROCESSING', GET00230
1/1X,'FUNCTION ON THE INPUT DC I-V CURVE DATA PRIOR TO USING', GET00240
2/1X,'THE PROGRAM SISCAP. OUTPUT FROM GETCHI IS THE PRE-', GET00250
3/1X,'PROCESSED DC I-V DATA, CHI IN AN APPROPRIATELY DIS-', GET00260
4/1X,'CRETIZED FORM AND VALUES FOR THE PARAMETERS: NOCHI,', GET00270
5/1X,'NOIV, NOPNTS AND RN')                          GET00280
C                                                    GET00290
C WRITE(6,20)                                       GET00300
20  FORMAT(/1X,'INPUT THE GAP VOLTAGE (VGAP) IN VOLTS OF THE SINGLE' GET00310
1/10X,'JUNCTION EQUIVALENT DEVICE (FORMAT E15.8)') GET00320
25  READ(5,25) VGAP                                  GET00330
C  FORMAT(E15.8)                                     GET00340
C                                                    GET00350
C CALL EVEN(VOLT2,CUR2,NUM,DELTAV)                   GET00360
C                                                    GET00370
C RSTART = 1.0E9                                     GET00380
C CALL REFINE(VOLT2,CUR2,NUM,RSTART,RFINIS)          GET00390
C                                                    GET00400
C CALL INEXP(VOLT2,CUR2,NUM,VOLT3,CUR3,NOCHI,NOPNTS) GET00410
C                                                    GET00420
C RSTART = RFINIS                                    GET00430
C CALL REFINE(VOLT3,CUR3,NOCHI,RSTART,RFINIS)        GET00440
C                                                    GET00450
C CALL IVTOCH(VOLT3,CUR3,NOCHI,DELTAV,TIME,CHI,CCHI,FACTOR) GET00460
C                                                    GET00470
C CALL REEXP(VOLT2,CUR2,NUM,VOLT4,CUR4,NOIV,DELTAV) GET00480
C                                                    GET00490
C WRITE(8,10) NOCHI                                  GET00500
10  FORMAT(I5)                                       GET00510
C                                                    GET00520
C DO 40 I = 1,NOCHI                                  GET00530
40  WRITE(8,30) TIME(I), CHI(I)                     GET00540
30  FORMAT(2E15.8)                                  GET00550

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```

C                                     GET00560
      WRITE(9,10) NOIV                                     GET00570
C                                     GET00580
      DO 50 I = 1,NOIV                                     GET00590
50    WRITE(9,30) VOLT4(I), CUR4(I)                       GET00600
C                                     GET00610
      WRITE(6,60) NOCHI, NOIV, NOPNTS, RFINIS            GET00620
60    FORMAT(/1X,'INFORMATION FOR TRANSFERRAL TO PROGRAM SISCAP:'
      1/1X,'OUTPUTTING THE CHI FILE ON UNIT 8: NOCHI = ',I5/
      21X,'OUTPUTTING THE IV FILE ON UNIT 9: NOIV = ',I5/
      31X,'NOPNTS = ',I5/
      41X,'RN = ',E15.8,' OHMS')                          GET00670
C                                     GET00680
      STOP                                                GET00690
      END                                                GET00700
      SUBROUTINE EVEN(VOLTV,CURV,NUM,DELTAV)              GET00710
      REAL CURV(NUM), VOLTV(NUM)                         GET00720
      LOGICAL FLAG                                       GET00730
      COMMON /GAPINF/ VGAP                               GET00740
C                                     GET00750
C      SUBROUTINE EVEN: THIS SUBROUTINE PROVIDES AN EVENLY SPACED
C      VERSION OF THE EXPERIMENTALLY OBTAINED INPUT I-V DATA.
C      LINEAR INTERPOLATION IS USED TO PROVIDE THE OUTPUT POINTS
C      THE EXPERIMENTAL DATA IS SCALED TO A SINGLE JUNCTION EQUIVALENT
C                                     GET00790
      DELTAV = 0.000005                                  GET00800
      NUM = 4096                                         GET00810
C                                     GET00820
C                                     GET00830
      READ(7,10,END=2000) NTMP                           GET00840
10    FORMAT(I5)                                         GET00850
      WRITE(6,2)                                         GET00860
      FORMAT(/1X,'INPUTTING THE INPUT I-V CURVE DATA FROM UNIT 7')
C                                     GET00870
C                                     GET00880
C      WRITE(6,5)                                         GET00890
C5    FORMAT(/1X,'SUBROUTINE EVEN: THIS SUBROUTINE PROVIDES AN EVENLY',
C      11X,'SPACED VERSION'/18X,'OF THE EXPERIMENTALLY OBTAINED INPUT I-V
C      2,' DATA'/18X,'LINEAR INTERPOLATION IS USED TO PROVIDE THE POINTS'
C      3/18X,'ON OUTPUT, THE EXPERIMENTAL DATA IS SCALED'/18X,'TO A',
C      4' SINGLE JUNCTION EQUIVALENT')
C                                     GET00940
C                                     GET00950
      WRITE(6,20)                                         GET00960
20    FORMAT(/1X,'INPUT THE NUMBER OF JUNCTIONS (NOJUN) IN DEVICE (I5)')
      READ(5,30) NOJUN                                    GET00970
30    FORMAT(I5)                                         GET00980
C                                     GET00990
C      ADJUST DELTAV TO CORRESPOND WITH A MULTI-JUNCTION DEVICE
C                                     GET01000
C                                     GET01010
      DELTAV = FLOAT(NOJUN) * DELTAV                    GET01020
C                                     GET01030
C                                     GET01040
      VOLT = 0.0                                         GET01050
      CUR = 0.0                                          GET01060
      V1 = 0.0                                           GET01070
      C1 = 0.0                                           GET01080
      FLAG = .FALSE.                                     GET01090
C                                     GET01100

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```

      READ(7,40) V2, C2
      FORMAT(2E15.8)
40    C
      IF(V2.NE.0.0 .OR. C2.NE.0.0) GO TO 3000
      C
      DO 100 I = 1,NUM
      VOLT(I) = VOLT / FLOAT(NOJUN)
      CURV(I) = CUR / FLOAT(NOJUN)
      VOLT = VOLT + DELTAV
50    IF(VOLT.LT.V2) GO TO 60
      IF(C2.LT.C1 .OR. V2.LT.V1) GO TO 4000
      V1 = V2
      C1 = C2
      IF(FLAG) GO TO 70
      READ(7,40,END=70) V2, C2
      GO TO 50
60    CUR = C1 + (C2 - C1) / (V2 - V1) * (VOLT - V1)
      GO TO 100
70    RTST = V2 / C2
      IF(V2.LT.2.0*VGAP*FLOAT(NOJUN)) GO TO 6000
      CUR = VOLT /RTST
      FLAG = .TRUE.
100   CONTINUE
      C
1000  RETURN
      C
2000  WRITE(6,2001)
2001  FORMAT(1X,'ERROR DETECTED IN SUBROUTINE EVEN'/
11X,'NO DATA FOUND IN IV FILE')
      STOP
3000  WRITE(6,3001)
3001  FORMAT(1X,'ERROR DETECTED IN SUBROUTINE EVEN'/
11X,'FIRST POINT IN IV EXPERIMENTAL DATA SHOULD BE 0.0,0.0')
      STOP
4000  WRITE(6,4001) V1, V2, C1, C2
4001  FORMAT(1X,'ERROR DETECTED IN SUBROUTINE EVEN'/
11X,'POINTS ARE NOT MONOTONICALLY INCREASING'/
21X,'VOLTAGE 1 = ',E15.8,5X,'VOLTAGE 2 = ',E15.8/
31X,'CURRENT 1 = ',E15.8,5X,'CURRENT 2 = ',E15.8)
      STOP
5000  WRITE(6,5001)
5001  FORMAT(1X,'ERROR DETECTED IN SUBROUTINE EVEN'/
11X,'RANGE OF GIVEN I-V DATA POINTS DOES NOT COVER REQD SPACE')
      STOP
6000  WRITE(6,6001)
6001  FORMAT(1X,'ERROR DETECTED IN SUBROUTINE EVEN'/
11X,'INPUT I-V CURVE DATA DOES NOT EXTEND FAR ENOUGH '/
21X,'INTO THE LINEAR RANGE')
      STOP
      END
      SUBROUTINE REFINE(VOL,CUR,NUM,RBEFOR,RAFTER)
      DIMENSION VOL(NUM), CUR(NUM)
      C
      C SUBROUTINE REFINE REMOVES THE OHMIC PORTION FROM THE I-V DATA SUCH
      C THAT THE LAST DATA POINT HAS ZERO CURRENT

```

```

GET01110
GET01120
GET01130
GET01140
GET01150
GET01160
GET01170
GET01180
GET01190
GET01200
GET01210
GET01220
GET01230
GET01240
GET01250
GET01260
GET01270
GET01280
GET01290
GET01300
GET01310
GET01320
GET01330
GET01340
GET01350
GET01360
GET01370
GET01380
GET01390
GET01400
GET01410
GET01420
GET01430
GET01440
GET01450
GET01460
GET01470
GET01480
GET01490
GET01500
GET01510
GET01520
GET01530
GET01540
GET01550
GET01560
GET01570
GET01580
GET01590
GET01600
GET01610
GET01620
GET01630
GET01640
GET01650

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C                                     GET01660
C   WRITE(6,90) NUM                   GET01670
C90  FORMAT(/1X,'SUBROUTINE REFINE: REMOVING THE OHMIC PORTION FROM', GET01680
C   1/20X,'I-V DATA SUCH THAT THE LAST POINT HAS ZERO CURRENT'/ GET01690
C   220X,'NUMBER OF POINTS PROCESSED = ',I5) GET01700
C                                     GET01710
C   GADD = CUR(NUM) / VOL(NUM)        GET01720
C                                     GET01730
C   DO 40 I = 1,NUM                   GET01740
40  CUR(I) = CUR(I) - GADD * VOL(I)   GET01750
C                                     GET01760
C   GBEFOR = 1./RBEFOR                GET01770
C   GAFTER = GBEFOR + GADD            GET01780
C   RAFTER = 1. / GAFTER              GET01790
C                                     GET01800
C   RETURN                             GET01810
C                                     GET01820
C   END                                 GET01830
C   SUBROUTINE INEXP(TIMIN,CHI,NUM,TOUT,CHOUT,NTOTAL,NOPNTS) GET01840
C   REAL TOUT(NTOTAL), CHOUT(NTOTAL)  GET01850
C   DIMENSION TIMIN(NUM), CHI(NUM)    GET01860
C   LOGICAL FLAG                       GET01870
C   COMMON /GAPINF/ VGAP               GET01880
C   DATA PI, HBAR, E/3.1415926,1.055E-34,1.602E-19/ GET01890
C   DATA TOL1, TOL2/1.E-7,1.E-3/    GET01900
C                                     GET01910
C   INTERPOLATION PROGRAM             GET01920
C                                     GET01930
C   SUBROUTINE INEXP INTERPOLATES THE I-V DATA SUCH THAT GET01940
C   THE SPACING AND NUMBER OF POINTS CORRESPOND TO THE GET01950
C   CORRECT SPACING FOR THE CHI CURVE GET01960
C                                     GET01970
C   THE INTERPOLATION FORMULA USED IS A + B*X + C*EXP(D*X) GET01980
C   EQUAL SPACED POINTS MUST BE USED GET01990
C                                     GET02000
C   FLAG = .FALSE.                   GET02010
C                                     GET02020
C   WRITE(6,700)                      GET02030
C700  FORMAT(/1X,'SUBROUTINE INEXP: INTERPOLATES THE I-V DATA SUCH', GET02040
C   11X,'THAT THE SPACING'/19X,'AND NUMBER OF POINTS CORRESPOND'/ GET02050
C   219X,'TO THE CORRECT SPACING FOR THE CHI CURVE'/) GET02060
C                                     GET02070
C   WRITE(6,720)                      GET02080
720  FORMAT(/1X,'INPUT THE LO FREQUENCY IN HERTZ (FREQ) (E15.8)') GET02090
C   READ(5,740) FPEQ                  GET02100
740  FORMAT(E15.8)                   GET02110
C   DELTA = E * VGAP / 2.0            GET02120
C   N1 = 2.0 * DELTA / (0.064*FREQ*2.0*PI*HBAR) GET02130
C   N2 = 260 / N1                    GET02140
C   WRITE(6,750) N2, N1              GET02150
750  FORMAT(/1X,'NUMBER OF LO CYCLES OF CHI IN SISCAP SHOULD BE', GET02160
C   11X,' > ',I5/                   GET02170
C   21X,'THE NUMBER OF POINTS PER LO CYCLE IN SISCAP ', GET02180
C   3'SHOULD BE > ',I5)             GET02190
C   WRITE(6,755)                     GET02200

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755  FORMAT(/1X,'INPUT NUMBER OF LO CYCLES (NOCYC) (I5)'/1X,'INPUT NO',GET02210
1' OF POINTS PER LO CYCLE (NOPNTS) (I5)')GET02220
      READ(5,760) NOCYC, NOPNTSGET02230
760  FORMAT(I5)GET02240
CGET02250
      DELTAT = 1. / FREQ / FLOAT(NOPNTS)GET02260
      DELTAW = 1.0/FLOAT(NOPNTS)/FLOAT(NOCYC)/DELTAT*2.0*PIGET02270
      DELTAV = HBAR * DELTAW / E / 2.0GET02280
      NTOTAL = NOCYC * NOPNTSGET02290
      VTOTAL = FLOAT(NTOTAL) * DELTAVGET02300
      WRITE(6,554) NTOTALGET02310
554  FORMAT(1X,'NOCHI = ',I5)GET02320
CGET02330
      WRITE(6,555) DELTAV, VTOTALGET02340
C555  FORMAT(1X,'DELTAV = ',E15.8,' VOLTS',1X,'TOTAL VOLTAGE REQD = ',GET02350
C      1E15.8,' VOLTS')GET02360
CGET02370
      TIME = 0.0GET02380
      IPNT = 2GET02390
      VAL = 0.0GET02400
      TGOUT(1) = TIMEGET02410
      CHOUT(1) = VALGET02420
CGET02430
      NLIMIT = NTOTAL - 1GET02440
      DO 100 I = 1,NLIMITGET02450
      TIME = TIME + DELTAVGET02460
      IF(FLAG) GO TO 410GET02470
60  IF(TIMIN(IPNT+1).GT.TIME) GO TO 70GET02480
      IPNT = IPNT + 1GET02490
      IF(IPNT+2.GT.NUM) GO TO 410GET02500
      GO TO 60GET02510
CGET02520
70  YM1 = CHI(IPNT-1)GET02530
      Y0 = CHI(IPNT)GET02540
      Y1 = CHI(IPNT+1)GET02550
      Y2 = CHI(IPNT+2)GET02560
      CURV1 = Y2 - 2.0*Y1 + Y0GET02570
      CURV2 = Y1 - 2.0*Y0 + YM1GET02580
      IF(CURV1*CURV2 .LT. 0.0) GO TO 470GET02590
      IF(ABS(CURV1).LE.TOL1 .OR. ABS(CURV2).LE.TOL1)GOTO470GET02600
      D = ALOG(CURV1/CURV2)GET02610
      IF(ABS(D).LT.TOL2) GO TO 470GET02620
      C = CURV1 / ((EXP(D)-1.0)**2)GET02630
      A = Y0 - CGET02640
      B = Y1 - A - C*EXP(D)GET02650
      X = (TIME-TIMIN(IPNT))/(TIMIN(IPNT+1)-TIMIN(IPNT))GET02660
      VAL = A + B*X + C*EXP(D*X)GET02670
      GO TO 400GET02680
CGET02690
470  VAL = (TIME-TIMIN(IPNT))/(TIMIN(IPNT+1)-TIMIN(IPNT))GET02700
      1 * (CHI(IPNT+1) - CHI(IPNT)) + CHI(IPNT)GET02710
CGET02720
      GO TO 400GET02730
410  FLAG = .TRUE.GET02740
      VAL = 0.0GET02750

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```

C
400 TOUT(I+1) = TIME
    CHOUT(I+1) = VAL
C
100 CONTINUE
C
    IF(.NOT.FLAG) RETURN
C
    PERCNT = TIMIN(NUM) / VTOTAL * 100.0
    WRITE(6,210) PERCNT
210  FORMAT(1X,'THE GIVEN POINTS WERE NOT SUFFICIENT TO COVER THE'
1,' REQD INTERP REGION'/1X,'THE FUNCTION WAS ASSUMED',
2,' TO BE ZERO FOR THE EXTRAPOLATED PORTION',/
31X,'THE INTERPOLATED REGION EQUALS ',F8.2,'% OF THE TOTAL RANGE')
    RETURN
C
    END
    SUBROUTINE IVTOCH(VOL,CURNEW,NOCHI,DELTA V,TIME,CHI,CCHI,FACTOR)
    REAL VOL(NOCHI), CURNEW(NOCHI), TIME(NOCHI), CHI(NOCHI)
    REAL LENGTH
    COMPLEX CCHI(NOCHI), FACTOR(NOCHI)
C
C THIS SUBROUTINE TRANSFORMS THE DISCRETIZED I-V DATA
C INTO THE EQUIVALENT DISCRETIZED CHI DATA
C
C WRITE(6,300)
C300  FORMAT(/1X,'SUBROUTINE IVTOCH: TRANSFORMING I-V DATA TO CHI DATA')
C
    IBASE = -9
    HBAR = 1.055E-34
    E = 1.602E-19
    NDIV2 = NOCHI
    N = NDIV2 * 2
    IF(N.EQ.512) GO TO 222
    IF(N.EQ.1024) GO TO 223
    IF(N.EQ.2048) GO TO 224
    IF(N.EQ.4096) GO TO 225
    IF(N.EQ.8192) GO TO 226
    WRITE(6,777) N
777  FORMAT(1X,'N DOES NOT EQUAL 512,1024,2048,4096,8192'
1/1X,'IT EQUALS ',I5)
    WRITE(6,799)
799  FORMAT(1X,'INPUT THE BINARY LOGARITHM OF THIS NUMBER')
    READ(5,778) IBASE
778  FORMAT(I5)
    GO TO 222
223  IBASE = -10
    GO TO 222
224  IBASE = -11
    GO TO 222
225  IBASE = -12
    GO TO 222
226  IBASE = -13
C
C SET UP DC VALUE AT ZERO ON I-V CURVE

```

GET02760
 GET02770
 GET02780
 GET02790
 GET02800
 GET02810
 GET02820
 GET02830
 GET02840
 GET02850
 GET02860
 GET02870
 GET02880
 GET02890
 GET02900
 GET02910
 GET02920
 GET02930
 GET02940
 GET02950
 GET02960
 GET02970
 GET02980
 GET02990
 GET03000
 GET03010
 GET03020
 GET03030
 GET03040
 GET03050
 GET03060
 GET03070
 GET03080
 GET03090
 GET03100
 GET03110
 GET03120
 GET03130
 GET03140
 GET03150
 GET03160
 GET03170
 GET03180
 GET03190
 GET03200
 GET03210
 GET03220
 GET03230
 GET03240
 GET03250
 GET03260
 GET03270
 GET03280
 GET03290
 GET03300

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```

C
222  TMP = CURNEW(1)
      VOL(1) = 0.
      CCHI(1) = CMPLX(0.,0.)
C
      DO 100 I = 2,NDIV2
      TMP = CURNEW(I)
      DELTAV = VOL(I) - VHLD
      VHLD = VOL(I)
      INEXT = N + 2 - I
      CCHI(INEXT) = CMPLX(0.,TMP)
100  CCHI(I) = CMPLX(0.,-TMP)
110  FORMAT(E15.8,E15.8)
      CCHI(NDIV2 + 1) = CMPLX(0.,0.)
C
      WRITE(6,446) DELTAV, NDIV2
C446  FORMAT(19X,'DELTAV INPUT IS ',E15.8,' VOLTS'/
C      119X,'NO OF POINTS INPUT = ',I5)
      DELTAF = DELTAV / HBAR / 2. / 3.1415926 * E
      FRMAX = DELTAF * FLOAT(NDIV2)
C
C      NYQUIST SAMPLING IS TWICE THAT OF MAX FREQUENCY IN W FORM
C
      DELTAT = 1. / (FRMAX * 2.)
      LENGTH = FRMAX * 2.
C
      CALL FFT(IBASE,CCHI,FACTOR)
C
      DO 200 I = 1,NDIV2
      TIME(I) = FLOAT(I-1) * DELTAT
C
C      THE VALUE OF LENGTH/FLOAT(N) EQUAL DELTAF
C
      CHI(I) = 2. * REAL(CCHI(I)) * LENGTH / FLOAT(N)
200  CONTINUE
C
      WRITE(6,310) DELTAT, NDIV2
C310  FORMAT(19X,'DELTAT ON OUTPUT = ',E15.8,' SECS'/
C      119X,'NO OF POINTS OUTPUT = ',I5)
C
      RETURN
      END
      SUBROUTINE FFT(NUMBER,DATA,FACTOR)
      INTEGER GRPSZE,POSN,POINTR,ELMTNO,FACPTR,ABSNUM
      INTEGER GPPTR
      LOGICAL INVERT
      COMPLEX TEMP,W,FACTOR(NUMBER),DATA(NUMBER),WSCALE,TEMP1,
1TEMP2
      DATA PI/3.1415926/
C
C      AUTHOR: R.G. HICKS, UNIV. OF QLD., APRIL 1977.
C
C      AIM: THIS SUBROUTINE PERFORMS A FAST FOURIER TRANSFORM ON THE
C           INPUT DATA USING THE COOLEY-TURKEY ALGORITHM
C           THERE MUST BE 2**NUMBER POINTS GIVEN

```

```

GET03310
GET03320
GET03330
GET03340
GET03350
GET03360
GET03370
GET03380
GET03390
GET03400
GET03410
GET03420
GET03430
GET03440
GET03450
GET03460
GET03470
GET03480
GET03490
GET03500
GET03510
GET03520
GET03530
GET03540
GET03550
GET03560
GET03570
GET03580
GET03590
GET03600
GET03610
GET03620
GET03630
GET03640
GET03650
GET03660
GET03670
GET03680
GET03690
GET03700
GET03710
GET03720
GET03730
GET03740
GET03750
GET03760
GET03770
GET03780
GET03790
GET03800
GET03810
GET03820
GET03830
GET03840
GET03850

```

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```

C          AND THE GIVEN POINTS ARE DESTROYED BY THE SUBROUTINE.      GET03860
C          IF NUMBER IS NEGATIVE, AN INVERSE FOURIER TRANSFORM IS DONE. GET03870
C
C          INVERT = .FALSE.      GET03880
          ABSNUM = NUMBER      GET03890
          IF(NUMBER.GT.0) GO TO 10 GET03900
          ABSNUM = -NUMBER      GET03910
          INVERT = .TRUE.      GET03920
10         N = 2 ** ABSNUM      GET03930
          ARG = 2. * PI / FLOAT(N) GET03940
          TEMP = CMPLX(0.,ARG) GET03950
          W = CEXP(TEMP)      GET03960
C
C          FACTOR(1) = W      GET03970
          NDIV2 = N/2      GET03980
          DO 15 INDEX = 2,NDIV2 GET03990
15         FACTOR(INDEX) = FACTOR(INDEX - 1)*W GET04000
C
          IF(INVERT) GO TO 20 GET04010
          DO 17 POSN = 1,N      GET04020
17         DATA(POSN) = CONJG(DATA(POSN)) GET04030
C
20         GRPSZ = N      GET04040
          NOGRP = 1      GET04050
          ITERNO = 0      GET04060
25         LIMIT = GRPSZ/2 GET04070
          ITERNO = ITERNO + 1 GET04080
          POINTR = GRPSZ/2 + 1 GET04090
          POSN = 1      GET04100
C
          DO 60 GRPTR = 1, NOGRP GET04110
          DO 50 ELMTNO = 1,LIMIT GET04120
          IPOSN = POSN - 1      GET04130
          CALL FACNO(IPOSN,N,ITERNO,FACPTR) GET04140
          IF(FACPTR.EQ.0) GO TO 30 GET04150
          WSCALE = FACTOR(FACPTR) GET04160
          TEMP1 = DATA(POINTR) * WSCALE + DATA(POSN) GET04170
          WSCALE = -WSCALE      GET04180
          TEMP2 = DATA(POINTR) * WSCALE + DATA(POSN) GET04190
          GO TO 40      GET04200
30         TEMP1 = DATA(POINTR) + DATA(POSN) GET04210
          TEMP2 = DATA(POSN) - DATA(POINTR) GET04220
40         DATA(POSN) = TEMP1      GET04230
          DATA(POINTR) = TEMP2      GET04240
          POSN = POSN + 1      GET04250
          POINTR = POINTR + 1      GET04260
50         POSN = POSN + GRPSZ/2      GET04270
          POINTR = POINTR + GRPSZ/2 GET04280
C
          GRPSZ = GRPSZ/2      GET04290
          NOGRP = NOGRP * 2      GET04300
          IF(GRPSZ .GT. 1) GO TO 25 GET04310
C
          DO 70 POSN = 1,N      GET04320
          GET04330
          GET04340
          GET04350
          GET04360
          GET04370
          GET04380
          GET04390
          GET04400

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```

      IPOSN = POSN - 1
      CALL JUXTA(N,IPOSN,JUXPOS)
      JUXPOS = JUXPOS + 1
      IF(JUXPOS.LT.FOSN) GO TO 70
      TEMP = DATA(POSN)
      DATA(POSN) = DATA(JUXPOS)
      DATA(JUXPOS) = TEMP
70    CONTINUE
C
      IF(INVERT) RETURN
      DO 80 POSN = 1,N
      TEMP = CONJG(DATA(POSN))
80    DATA(POSN) = TEMP / N
C
      RETURN
      END
      SUBROUTINE JUXTA(N,IPOSN,JUXPOS)
C
C      THIS SUBROUTINE DETERMINES THE CORRECT MULTIPLICATION SEQUENCING
C      IN THE BUTTERFLY ALGORITHM OF THE FAST FOURIER TRANSFORM
C
      NN = N
      NUM = IPOSN
      JUXPOS = 0
C
      DO 10 I=1,N
      NN = NN/2
      MEM = NUM
      NUM = NUM/2
      IREM = MEM - 2*NUM
      JUXPOS = 2*JUXPOS + IREM
      IF(NN.EQ.1) GO TO 20
10    CONTINUE
20    RETURN
      END
      SUBROUTINE FACNO(IPOSN,N,ITERNO,FACPTR)
      INTEGER FACPTR
C
C      THIS SUBROUTINE DETERMINES THE CORRECT FACTOR FOR CORRECT
C      CALCULATION OF THE BUTTERFLY ALGORITHM IN THE FAST FOURIER TRANSFO
C
      FACPTR = 0
      IDIV = N/(2**ITERNO)
      ITEMP = IPOSN
      ITEMP = ITEMP/IDIV
      MUL = N/2
      DO 10 I=1,ITERNO
      IREM = ITEMP - ITEMP/2*2
      FACPTR = IREM*MUL + FACPTR
      ITEMP = ITEMP/2
      MUL = MUL/2
10    CONTINUE
      RETURN
      END
      SUBROUTINE REEXP(TIMIN,CHI,NUM,TNEW,CHNEW,NOIV,DELTAV)

```

```

GET04410
GET04420
GET04430
GET04440
GET04450
GET04460
GET04470
GET04480
GET04490
GET04500
GET04510
GET04520
GET04530
GET04540
GET04550
GET04560
GET04570
GET04580
GET04590
GET04600
GET04610
GET04620
GET04630
GET04640
GET04650
GET04660
GET04670
GET04680
GET04690
GET04700
GET04710
GET04720
GET04730
GET04740
GET04750
GET04760
GET04770
GET04780
GET04790
GET04800
GET04810
GET04820
GET04830
GET04840
GET04850
GET04860
GET04870
GET04880
GET04890
GET04900
GET04910
GET04920
GET04930
GET04940
GET04950

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FILE: GETCHI FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

REAL TNEW(NOIV), CHNEW(NOIV)
DIMENSION TIMIN(NUM), CHI(NUM)
LOGICAL FLAG
COMMON /GAPINF/ VGAP
DATA TOL1, TOL2/1.E-7,1.E-3/
C
C INTERPOLATION PROGRAM
C
C THIS SUBROUTINE INTERPOLATES THE DATA SUCH THAT THE VECTOR
C J MAY BE CALCULATED WITH REASONABLE ACCURACY.
C TYPICALLY DELTAV SHOULD BE (VGAP/3.0E-3)*2.0E-5 VOLTS
C SHOULD BE USED.
C
C THE INTERPOLATION FORMULA USED IS A + B*X + C*EXP(D*X)
C
C THE POINTS USED MUST BE EQUALLY SPACED
C
C FLAG = .FALSE.
C VSUG = (VGAP/3.0E-3) * 0.00002
C
C WRITE(6,30)
C30 FORMAT(/1X,'SUBROUTINE REEXP: PROVIDES THE OUTPUT IV DATA',
C 1,' FOR PROGRAM SISCAP')
C WRITE(6,40) VSUG
C40 FORMAT(/1X,'INPUT DELTAV (TYP ',E11.4,' VOLTS) (E15.8)'/
C 11X,'INPUT NUMBER OF POINTS REQUIRED (NOIV) (PWR OF 2) (TYP 1024)',
C 2' (15)')
C50 READ(5,50) DELTAV, NOIV
C50 FORMAT(E15.8/15)
C
C NTOTAL = NOIV
C VTOTAL = FLOAT(NTOTAL) * DELTAV
C
C TIME = 0.
C IPNT = 2
C VAL = 0.
C TNEW(1) = TIME
C CHNEW(1) = VAL
C
C NLIMIT = NTOTAL - 1
C DO 100 I = 1,NLIMIT
C TIME = TIME + DELTAV
C IF(FLAG) GO TO 410
C60 IF(TIMIN(IPNT+1).GT.TIME) GO TO 70
C IPNT = IPNT + 1
C IF(IPNT+2.GT.NUM) GO TO 410
C GO TO 60
C
C70 YM1 = CHI(IPNT-1)
C Y0 = CHI(IPNT)
C Y1 = CHI(IPNT+1)
C Y2 = CHI(IPNT+2)
C CURV1 = Y2 - 2.0*Y1 + Y0
C CURV2 = Y1 - 2.0*Y0 + YM1

```

```

GET04960
GET04970
GET04980
GET04990
GET05000
GET05010
GET05020
GET05030
GET05040
GET05050
GET05060
GET05070
GET05080
GET05090
GET05100
GET05110
GET05120
GET05130
GET05140
GET05150
GET05160
GET05170
GET05180
GET05190
GET05200
GET05210
GET05220
GET05230
GET05240
GET05250
GET05260
GET05270
GET05280
GET05290
GET05300
GET05310
GET05320
GET05330
GET05340
GET05350
GET05360
GET05370
GET05380
GET05390
GET05400
GET05410
GET05420
GET05430
GET05440
GET05450
GET05460
GET05470
GET05480
GET05490
GET05500

```

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```

      IF(CURV1*CURV2 .LT. 0.0) GO TO 470
      IF(ABS(CURV1).LE.TOL1 .OR. ABS(CURV2).LE.TOL1)GOTO470
      D = ALOG(CURV1/CURV2)
      IF(ABS(D).LT.TOL2) GO TO 470
      C = CURV1 / ((EXP(D)-1.0)**2)
      A = Y0 - C
      B = Y1 - A - C*EXP(D)
      X = (TIME-TIMIN(IPNT))/(TIMIN(IPNT+1)-TIMIN(IPNT))
      VAL = A + B*X + C*EXP(D*X)
      GO TO 400
C
470  VAL = (TIME-TIMIN(IPNT))/(TIMIN(IPNT+1)-TIMIN(IPNT))
      1 * (CHI(IPNT+1) - CHI(IPNT)) + CHI(IPNT)
C
      GO TO 400
410  FLAG = .TRUE.
      VAL = 0.0
C
400  TNEW(I+1) = TIME
      CHNEW(I+1) = VAL
100  CONTINUE
C
      IF(.NOT.FLAG) RETURN
C
      PERCNT = TIMIN(NUM) / VTOTAL * 100.0
      WRITE(6,210) PERCNT
210  FORMAT(1X,'THE GIVEN POINTS WERE NOT SUFFICIENT TO COVER THE'
1,' REQD INTERP REGION'/1X,'THE FUNCTION WAS ASSUMED',
2,' TO BE ZERO FOR THE EXTRAPOLATED PORTION',/
31X,'THE INTERPOLATED REGION EQUALS ',F8.2,'% OF THE TOTAL RANGE')
      RETURN
C
      END

```

```

GET05510
GET05520
GET05530
GET05540
GET05550
GET05560
GET05570
GET05580
GET05590
GET05600
GET05610
GET05620
GET05630
GET05640
GET05650
GET05660
GET05670
GET05680
GET05690
GET05700
GET05710
GET05720
GET05730
GET05740
GET05750
GET05760
GET05770
GET05780
GET05790
GET05800
GET05810
GET05820
GET05830

```

A.8 Listing of Program SISCAP

This section gives the listing of the SIS mixer analysis program

SISCAP.

FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

COMPLEX ZIMPED(128), VSOURC(128)                SIS00010
COMPLEX CVAL(128), FACTOR(2048), J(1024), ZSSB(127)  SIS00020
COMPLEX Y0, Y1, Y1M, FIDDLE, ZLO, CHOLD          SIS00030
REAL VOLT(128), CHI(512), CUR(128), OLDDVOL(128)  SIS00040
REAL IVDAT(1024)                                SIS00050
LOGICAL FLAG                                     SIS00060
COMMON /PERIPH/ IN, IOUT, IPLOT                  SIS00070
COMMON /ERRALL/ TOL, EPS                         SIS00080
COMMON /RBOU/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, RLOSS, RTEMP SIS00090
DATA E/1.602E-19/, HBAR/1.055E-34/, PI/3.1415926/  SIS00100
C
IN = 5                                           SIS00120
IOUT = 6                                        SIS00130
IPLOT = 20                                     SIS00140
C
OBTAIN THE VARIOUS INPUT PARAMETERS, BOTH JUNCTION AND ALGORITHM  SIS00160
PARAMETERS                                     SIS00170
C
READ(11,1) ISIG, NODAT, DELV, VSTART, VLOSTR, DELVLO, NLO, TOL,  SIS00180
1 EPS, NOPNTS, IBASE1, NOIV, IBASE2, NOCHI, NOPER, MMAX, NMAX,  SIS00200
2 RN, CAP, TEMP, FREQ, FIF, P, RID, Z0         SIS00210
1 FORMAT(15/15,4(/E15.8),/15,2(/E15.8),8(/15),8(/E15.8))  SIS00220
C
NOCOL = 4                                       SIS00240
C
WRITE(IPLOT,4001) NODAT, NOCOL                 SIS00260
C4001 FORMAT(2I5)                               SIS00270
C
WRITE(6,700) FREQ,FIF,CAP,RN,TEMP,IBASE2,NOIV,IBASE1,NOPNTS,MMAX,  SIS00290
1NMAX, ISIG, NOPER, NOCHI, NODAT, TOL, EPS, DELV, VSTART,  SIS00300
2VLOSTR, DELVLO, NLO, P, RID, Z0              SIS00310
700 FORMAT(/1X,'FREQ = ',E15.8,'HZ',1X,'FIF = ',E15.8,'HZ'/  SIS00320
11X,'CAP = ',E15.8,'F ',1X,'RN = ',E15.8,'OHMS'/  SIS00330
21X,'TEMP = ',E15.8,'K '/  SIS00340
31X,'IBASE2 = ',15,1X,'NOIV = ',15/  SIS00350
41X,'IBASE1 = ',15,1X,'NOPNTS = ',15/  SIS00360
51X,'MMAX = ',15,1X,'NMAX = ',15/  SIS00370
61X,'ISIG = ',15,1X,'NOPER = ',15/  SIS00380
71X,'NOCHI = ',15,1X,'NODAT = ',15/  SIS00390
81X,'TOL = ',E15.8,9X,'EPS = ',E15.8/  SIS00400
91X,'DELV = ',E15.8,'VOLTS',3X,'VSTART = ',E15.8,'VOLTS'/  SIS00410
11X,'VLOSTR = ',E15.8,'VOLTS',1X,'DELVLO = ',E15.8,'VOLTS'/  SIS00420
11X,'NLO = ',15,19X,'P = ',E15.8/  SIS00430
21X,'RID = ',E15.8,'OHMS',5X,'Z0 = ',E15.8,'OHMS')  SIS00440
C
CHECK THE VALIDITY OF CONTROL PARAMETERS        SIS00450
C
IF(FREQ.LE.FIF) GO TO 8002                      SIS00480
IF(FIF.LE.0) GO TO 8002                        SIS00490
IF(2**IBASE2.NE.NCIV) GO TO 8002              SIS00500
IF(2**IBASE1.NE.NOPNTS) GO TO 8002            SIS00510
IF(MMAX.GT.NOPNTS/2-1) GO TO 8002             SIS00520
IF(NMAX.GT.NOPNTS/2-1) GO TO 8002             SIS00530
IF(NOCHI.LT.NOPNTS) GO TO 8002                SIS00540
IF(ISIG.LE.0.OR.ISIG.GT.3) GO TO 8002        SIS00550

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C		SIS00560
C	OBTAIN THE CHI FUNCTION BY READING IT FROM DEVICE 4	SIS00570
C		SIS00580
	REWIND 4	SIS00590
	WRITE(6,601)	SIS00600
601	FORMAT(/1X,'INPUTTING THE CHI FUNCTION')	SIS00610
	READ(4,50) NFINAL	SIS00620
50	FORMAT(15)	SIS00630
	IF(NFINAL.NE.NOCHI) GO TO 8000	SIS00640
	DUMHLD = 0.0	SIS00650
	DO 70 I = 1,NFINAL	SIS00660
	READ(4,80) TMP, CHI(I)	SIS00670
80	FORMAT(2E15.8)	SIS00680
	DELTAT = TMP - DUMHLD	SIS00690
	DUMHLD = TMP	SIS00700
70	CONTINUE	SIS00710
	WRITE(6,602) DELTAT, NFINAL	SIS00720
602	FORMAT(1X,'DELTAT = ',E15.8,' SECS'/	SIS00730
	11X,'NUMBEP OF POINTS READ = ',I5)	SIS00740
C		SIS00750
C	OBTAIN THE SIS I-V CHARACTERISTIC BY READING IT FROM DEVICE 8	SIS00760
C		SIS00770
	REWIND 8	SIS00780
498	WRITE(6,501)	SIS00790
501	FORMAT(/1X,'INPUTTING THE SIS IV CHARACTERISTIC')	SIS00800
	READ(8,100) NDUM	SIS00810
100	FORMAT(15)	SIS00820
	IF(NDUM.NE.NOIV) GO TO 7000	SIS00830
	DUMHLD = 0.0	SIS00840
	DO 110 II = 1,NDUM	SIS00850
	READ(8,120) DUMMY, IVDAT(II)	SIS00860
120	FORMAT(2E15.8)	SIS00870
	DELTAV = DUMMY - DUMHLD	SIS00880
	DUMHLD = DUMMY	SIS00890
110	CONTINUE	SIS00900
	WRITE(6,507) DELTAV, NDUM	SIS00910
507	FORMAT(1X,'DELTAV = ',E15.8,' VOLTS'/	SIS00920
	11X,'NUMBEP OF POINTS READ = ',I5)	SIS00930
C		SIS00940
C	CALCULATE THE VECTOR J	SIS00950
C		SIS00960
	WRITE(6,502)	SIS00970
502	FORMAT(/1X,'CALCULATING THE VECTOR J')	SIS00980
	CALL GETJ(IVDAT,NOIV,FREQ,IBASE2,J,FACTOR,RN,DELTAV)	SIS00990
C		SIS01000
C	INITIALIZE TO ZERO THE JUNCTION VOLTAGE VECTOR	SIS01010
C		SIS01020
	DO 10 I = 1,NOPNTS	SIS01030
	OLDVOL(I) = 0.	SIS01040
10	VOLT(I) = 0.	SIS01050
C		SIS01060
C	INPUT THE HARMONIC IMPEDANCES FROM UNIT NO. 15	SIS01070
C		SIS01080
	WRITE(6,603)	SIS01090
603	FORMAT(/1X,'INPUTTING THE LO HARMONIC IMPEDANCES')	SIS01100

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```

CALL GETZ(ZIMPED,NOPNTS,FREQ,CAP,VSOURC)
ZLO = ZIMPED(2)
C
C GET THE SIDEBAND IMPEDANCES FROM UNIT 14
C
WRITE(6,499)
499 FORMAT(/IX,'INPUTTING SIDEBAND TERMINATION INFORMATION')
CALL GETSSB(ZSSB,NOPNTS,FREQ,FIF,CAP)
Y0 = CMPLX(1.0,0.0) / ZSSB(1)
Y1 = CMPLX(1.0,0.0) / ZSSB(2)
Y1M = CMPLX(1.0,0.0) / CONJG(ZSSB(3))
C
VLO = VLOSTR - DELVLO
DO 5000 LIM = 1,NLO
VLO = VLO + DELVLO
C
VDC = VSTART - DELV
C
C RUN THE LARGE SIGNAL ANALYSIS PROGRAM 'NODAT' TIMES
C FOR EACH DC VOLTAGE BIAS POINT TO BE CONSIDERED
C
DO 5000 KIM = 1,NODAT
KKIMM = KIM + (LIM - 1) * NODAT
WRITE(6,6000) KKIMM
6000 FORMAT(/IX,'*****'/
11X,'*****CASE ',I3,'*****'/
21X,'*****'/)
VDC = VDC + DELV
C
WRITE(6,607) VDC, VLO
607 FORMAT(/IX,'EMBEDDING THEVENIN VDC SOURCE',8X,'= ',E15.8,' VOLTS'/
11X,'EMBEDDING THEVENIN VLO SOURCE (PEAK) = ',E15.8,' VOLTS')
C
VJDC = 0.0
VJLO = 0.0
CURDC = 0.0
CURPMP = 0.0
RLOSS = 0.0
RTEMP = 0.0
C
C DETERMINE WHICH METHOD OF ANALYSIS IS REQUIRED
C
C 1 = THREE FREQUENCY MODEL ASSUMPTION
C 2 = VOLTAGE UPDATE GENERAL ANALYSIS
C 3 = MULTIPLE REFLECTION GENERAL ANALYSIS TECHNIQUE
C
GO TO (9000,4000,4000), ISIG
C
C FOR THE 3-PORT ANALYSIS METHOD
C
9000 VJDC = VDC
VJLO = VLO
C
ARG = 2.0 * PI / FLOAT(NOPNTS)
DC 7777 MNZ = 1,NOPNTS

```

```

SIS01110
SIS01120
SIS01130
SIS01140
SIS01150
SIS01160
SIS01170
SIS01180
SIS01190
SIS01200
SIS01210
SIS01220
SIS01230
SIS01240
SIS01250
SIS01260
SIS01270
SIS01280
SIS01290
SIS01300
SIS01310
SIS01320
SIS01330
SIS01340
SIS01350
SIS01360
SIS01370
SIS01380
SIS01390
SIS01400
SIS01410
SIS01420
SIS01430
SIS01440
SIS01450
SIS01460
SIS01470
SIS01480
SIS01490
SIS01500
SIS01510
SIS01520
SIS01530
SIS01540
SIS01550
SIS01560
SIS01570
SIS01580
SIS01590
SIS01600
SIS01610
SIS01620
SIS01630
SIS01640
SIS01650

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      PHASE = ARG * FLOAT(MNZ -1)
7777 VOLT(MNZ) = VDC - VLO * COS(PHASE)
C
      WRITE(6,8888)
8888 FORMAT(/1X,'PERFORMING A 3-PORT ANALYSIS METHOD')
      GO TO 3000
C
C     FOR THE GENERAL ANALYSIS METHOD
C
4000 VSOURC(1) = VDC
      VSOURC(2) = VLO/2.
C
C     BCAP = 2. * PI * FREQ * CAP
C     FIDDLE = ZLO * CMPLX(0.,BCAP) + CMPLX(1.0,0.0)
C     VSOURC(2) = VSOURC(2) / FIDDLE
C
      RSOURC = REAL(ZLO)
      PLO = (CABS(VSOURC(2))**2) / 2. / RSOURC
      WRITE(6,4002) PLO
4002 FORMAT(/1X,'INCIDENT LOCAL OSCILLATOR POWER = ',E15.8,' WATTS'/)
C
      IF(1SIG.E0.2) GO TO 6003
C
C     FOR THE MULTIPLE REFLECTION TECHNIQUE
C
      CALL MRT(VOLT,CUR,NOPNTS,IBASE1,CHI,NOCHI,RN,
1FACTOR,FREQ,ZIMPED,VSOURC,OLDVOL,FLAG,Z0,NOPER)
C
      IF(FLAG) GO TO 5001
C
      DO 4321 MGM = 1,NOPNTS
4321 WRITE(6,4322) MGM, VOLT(MGM), CUR(MGM)
4322 FORMAT(1X,'POINT NO. = ',I5,'VOLTAGE = ',E15.8,'CURRENT = ',E15.8)
C
      GO TO 6001
C
C     FOR THE VOLTAGE UPDATE METHOD
C
6003 WRITE(6,604)
604  FORMAT(/1X,'GENERAL NONLINEAR ANALYSIS USING VOLTAGE UPDATE',
1' METHOD'/1X,'BEGINNING THE ITERATION PHASE')
C
      DO 1000 I = 1,NOPER
C
      WRITE(6,400) I
400  FORMAT(/8X,'ITERATION NUMBER = ',I5)
C
      CALL SISNL(VOLT,CUR,NOPNTS,IBASE1,CHI,NOCHI,RN,FACTOR,FREQ,RID)
      CALL LINEAR(VOLT,CUR,NOPNTS,IBASE1,FACTOR,ZIMPED,VSOURC,RID)
      CALL COMPAR(VOLT,CLDVOL,NOPNTS,FLAG)
C
      DO 500 JJ = 1,NOPNTS
500  OLDVOL(JJ) = P * VOLT(JJ) + (1.0 - P) * OLDVOL(JJ)
C
      IF(.NOT. FLAG) GO TO 2000

```

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C		SIS02210
1000	CONTINUE	SIS02220
C		SIS02230
	WRITE(6,606) NOPER	SIS02240
606	FORMAT(/8X,'LARGE SIGNAL ANALYSIS DID NOT CONVERGE IN ',I5,'ITNS')	SIS02250
	GO TO 5001	SIS02260
C		SIS02270
2000	WRITE(6,2002) I	SIS02280
2002	FORMAT(/1X,'LARGE SIGNAL ANALYSIS COMPLETED IN ',I5,'ITNS'/)	SIS02290
C		SIS02300
C	CORRECT FOR THE IDENTITY ELEMENT IN THE VOLTAGE	SIS02310
C	UPDATE METHOD	SIS02320
C		SIS02330
6002	DO 9002 IM = 1,NOPNTS	SIS02340
9002	CUR(IM) = CUR(IM) + VOLT(IM) / RID	SIS02350
C		SIS02360
	DO 4323 MGM = 1,NOPNTS	SIS02370
4323	WRITE(6,4322) MGM, VOLT(MGM), CUR(MGM)	SIS02380
C		SIS02390
C	DETERMINE THE NONLINEAR OPERATING POINT PARAMETERS	SIS02400
C	FROM THE RESULTS OF THE GENERAL ANALYSIS	SIS02410
C		SIS02420
6001	DO 2010 IM = 1,NOPNTS	SIS02430
	CVAL(IM) = VOLT(IM)	SIS02440
2010	CONTINUE	SIS02450
	CALL FFT(IBASE1,CVAL,FACTOR)	SIS02460
	VJDC = REAL(CVAL(1))	SIS02470
	VJLO = CABS(CVAL(2)) * 2.0	SIS02480
C		SIS02490
	VBIAS = VJDC	SIS02500
	VNORM = E * VBIAS / HBAR	SIS02510
	CALL EVALJ(VNORM,CHOLD,J,NOIV,DELTAV,RN)	SIS02520
	CURDC = AIMAG(CHOLD)	SIS02530
C		SIS02540
C	SMALL SIGNAL ANALYSIS SECTION	SIS02550
C		SIS02560
C	DO THE SMALL SIGNAL CONVERSION AND NOISE ANALYSIS	SIS02570
C		SIS02580
3000	CALL TOPS(FREQ,FIF,IBASE2,NOIV,IBASE1,NOPNTS,MMAX,CAP,RN,TEMP, 1NMAX,VOLT,Y0,Y1,YIM,ZLO,IVDAT,J,FACTOR,DELTAV,ISIG,ZSSB)	SIS02590
C		SIS02610
C5001	WRITE(IPLOT,4500) VJDC, CURDC, CURPMP, RLOSS, RTEMP	SIS02620
C4500	FORMAT(5E15.8)	SIS02630
C		SIS02640
5001	CONTINUE	SIS02650
C		SIS02660
5000	CONTINUE	SIS02670
C		SIS02680
	STOP	SIS02690
C		SIS02700
7000	WRITE(6,1001)	SIS02710
1001	FORMAT(1X,'PROBLEM WITH NUMBER OF POINTS IN IVDAT FILE')	SIS02720
	STOP	SIS02730
C		SIS02740
8000	WRITE(6,8001)	SIS02750

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8001  FORMAT(1X,'PROBLEM WITH NUMBER OF POINTS IN NOCHI FILE')          SIS02760
      STOP                                                                SIS02770
C                                                                SIS02780
8002  WRITE(6,8003)                                                       SIS02790
8003  FORMAT(1X,'ERROR DETECTED IN CONTROL PARAMETERS')                 SIS02800
      STOP                                                                SIS02810
C                                                                SIS02820
      END                                                                SIS02830
      SUBROUTINE GETSSB(ZSSB,NOPNTS,FREQ,FIF,CAP)                          SIS02840
      COMPLEX ZSSB(NOPNTS), YCAP                                         SIS02850
      COMPLEX YSIG, YIM                                                  SIS02860
      DATA PI/3.1415926/                                               SIS02870
      DATA NOPRT/10/                                                  SIS02880
C                                                                SIS02890
C      READ IN THE SIDEBAND IMPEDANCES FROM UNIT NUMBER                 SIS02900
C      14.  THE ORDER OF THE IMPEDANCE DATA IS IF,                     SIS02910
C      USB NO.1, LSB NO.1, USB NO.2, LSB NO.2, AND SO ON                SIS02920
C                                                                SIS02930
      READ(14,1101) NCHK                                                SIS02940
1101  FORMAT(I5)                                                         SIS02950
C      IF(NCHK.NE.NOPNTS-1) GO TO 8000                                    SIS02960
      NOMINI = NOPNTS - 1                                               SIS02970
      READ(14,1120) ZSSB(1)                                             SIS02980
1120  FORMAT(2E15.8)                                                    SIS02990
      WRITE(6,300) NOPRT, ZSSB(1)                                       SIS03000
300   FORMAT(1X,'THE FIRST ',I3,' SIDEBAND IMPEDANCES (EXC CAPAC): ',  SIS03010
      1/1X,'      0 ',E15.8,'+J',E15.8,'OHMS')                          SIS03020
      DO 801 II = 2,NOMINI                                               SIS03030
      ZSSB(II) = CMPLX(0.0,0.0)                                          SIS03040
      ISDBD = II / 2                                                    SIS03050
      IF(ISDBD*2.NE.II .AND. II.NE.1) ISDBD = -ISDBD                   SIS03060
      IF(II.GT.NCHK) GO TO 2000                                         SIS03070
      READ(14,1120) ZSSB(II)                                             SIS03080
2000  IF(II.LE.NOPRT) WRITE(6,301) ISDBD, ZSSB(II)                    SIS03090
301   FORMAT(1X,I5,1X,E15.8,'+J',E15.8,'OHMS')                        SIS03100
      IF(II/2*2.NE.II) ZSSB(II) = CONJG(ZSSB(II))                      SIS03110
801   CONTINUE                                                         SIS03120
C                                                                SIS03130
C      ADD IN THE JUNCTION PARASITIC CAPACITANCE CONTRIBUTION          SIS03140
C                                                                SIS03150
      CON = 2. * PI * CAP                                               SIS03160
      DO 398 II = 1,NCHK                                                SIS03170
      IF(CABS(ZSSB(II)) .LT. 1.E-10) GO TO 398                          SIS03180
      M = II / 2                                                         SIS03190
      IF(M.EQ.1 .OR. M.EQ.0) GO TO 398                                   SIS03200
      IF(M*2.NE.II.AND.II.NE.1) M = -M                                  SIS03210
      BCAP = (FLOAT(M)*FREQ + FIF) * CON                                  SIS03220
      YCAP = CMPLX(0.,BCAP)                                             SIS03230
      ZSSB(II) = 1./(1./ZSSB(II) + YCAP)                                 SIS03240
398   CONTINUE                                                         SIS03250
C                                                                SIS03260
      YSIG = CMPLX(1.0,0.0) / ZSSB(2)                                    SIS03270
      YIM = CMPLX(1.0,0.0) / ZSSB(3)                                    SIS03280
      WRITE(6,7000) YSIG, YIM                                           SIS03290
7000  FORMAT(1X,'Y SIGNAL (INCL CAPAC) = ',E15.8,' +J ',E15.8,'S'/1X,  SIS03300

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FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

      1'Y IMAGE (INCL CAPAC) = ',E15.8,' +J ',E15.8,'S')
C
      WRITE(6,200) NCHK
200  FORMAT(1X,'NUMBER OF POINTS READ = ',I5)
      RETURN
C
C8000  WRITE(6,8001)
C8001  FORMAT(1X,'PROBLEM WITH NUMBER OF POINTS IN ZSSB FILE')
C
      STOP
      END
      SUBROUTINE GETZ(ZIMPED,NOPNTS,FREQ,CAP,VSOURC)
      COMPLEX ZIMPED(NOPNTS), ZCAP, VSOURC(NOPNTS)
      COMPLEX YPMP
      DATA PI/3.1415926/
      DATA NOPRT /10/
C
C      READ IN FROM UNIT NO. 15 THE EMBEDDING IMPEDANCES
C      AT THE LO AND ITS HARMONICS
C
      CONST = 2. * PI * FREQ * CAP
      NODIV2 = NOPNTS/2
C
      READ(15,100) NCHK
100  FORMAT(I5)
C      IF(NCHK.NE.NODIV2) GO TO 1000
C
      READ(15,150) ZIMPED(1)
      WRITE(6,300) NOPRT, ZIMPED(1)
300  FORMAT(1X,'THE FIRST ',I3,' LO HARM IMPEDANCES (EXC CAPAC) ARE: '
1/1X,'      ',E15.8,'+J',E15.8,'OHMS')
      DO 10 I = 2,NODIV2
      ZIMPED(I) = CMPLX(0.,0.)
      IMIN1 = I - 1
      IF(I.GT.NCHK) GO TO 2000
      READ(15,150) ZIMPED(I)
150  FORMAT(2E15.8)
2000  IF(I.LE.NOPRT) WRITE(6,301) IMIN1, ZIMPED(I)
301  FORMAT(1X,I5,1X,E15.8,'+J',E15.8,'OHMS')
      IF(I.EQ.2) GO TO 10
C
C      ADD IN THE JUNCTION PARASITIC CAPACITANCE CONTRIBUTION
C
      XCAP = -1. / CONST / FLOAT(I-1)
      ZCAP = CMPLX(0.,XCAP)
      IF(CABS(ZIMPED(I)).LT.1.0E-10) GO TO 10
      ZIMPED(I) = 1. / (1./ZIMPED(I) + 1./ZCAP)
10  CONTINUE
      YPMP = CMPLX(1.,0.) / ZIMPED(2)
      WRITE(6,110) YPMP
110  FORMAT(1X,'Y PUMP (INCL CAPAC) = ',E15.8,' +J ',E15.8,'S')
C
C      ZERO OUT THE SOURCE VOLTAGE VECTOR
C
      DO 20 I = 1,NODIV2
20  VSOURC(I) = CMPLX(0.,0.)

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SIS03310
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SIS03850

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```

C
C
200 WRITE(6,200) NCHK
      FORMAT(1X,'NUMBER OF POINTS READ = ',I5)
      RETURN
C
C1000 WRITE(6,1001)
C1001 FORMAT(1X,'ERROR IN NUMBER OF POINTS IN ZLO FILE')
C
C STOP
C
C END
SUBROUTINE LINEAR(VOLT,CUR,NOPNTS,IBASE,FACTOR,ZIMPED,VSOURC,RID)
REAL VOLT(NOPNTS), CUR(NOPNTS)
COMPLEX FACTOR(NOPNTS), ZIMPED(NOPNTS), CTEMP(128), VSOURC(NOPNTS)
COMMON /REOUT/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, RLOSS, RTEMP
C
C THIS IS THE LINEAR EMBEDDING NETWORK CALCULATION PART
C OF THE VOLTAGE UPDATE METHOD
C
C DO 10 I = 1,NOPNTS
10 CTEMP(I) = -CUR(I)
C
C CALL FFT(IBASE,CTEMP,FACTOR)
C
C OBTAIN THE PUMPED I-V CURVE CURRENT VALUE ON THE WAY THROUGH
C
C CURPMP = -REAL(CTEMP(1))
C
C DON'T FORGET TO TAKE INTO ACCOUNT THE EFFECT OF
C THE IDENTITY ELEMENT
C
C NODIV2 = NOPNTS/2
C DO 20 I = 1,NODIV2
CTEMP(I) = CTEMP(I)*(ZIMPED(I)*RID)/(ZIMPED(I)+RID) +
1VSOURC(I) * RID / (ZIMPED(I) + RID)
IF(I.EQ.1) GO TO 20
ICORR = NOPNTS - I + 2
CTEMP(ICORR) = CONJG(CTEMP(I))
20 CONTINUE
CTEMP(NODIV2+1) = CMPLX(0.,0.)
C
C CALL ZERO(CTEMP,NOPNTS)
C
C COMPENSATE FOR THE IDENTITY ELEMENT WHEN DETERMINING
C THE PUMPED I-V CURVE CURRENT VALUE
C
C CURPMP = CURPMP + REAL(CTEMP(1)) / RID
C
C INTER = -IBASE
CALL FFT(INTER,CTEMP,FACTOR)
C
C DO 30 I = 1,NOPNTS
30 VOLT(I) = REAL(CTEMP(I))
C
C RETURN

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SIS03990
SIS04000
SIS04010
SIS04020
SIS04030
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SIS04090
SIS04100
SIS04110
SIS04120
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SIS04140
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SIS04160
SIS04170
SIS04180
SIS04190
SIS04200
SIS04210
SIS04220
SIS04230
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SIS04270
SIS04280
SIS04290
SIS04300
SIS04310
SIS04320
SIS04330
SIS04340
SIS04350
SIS04360
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SIS04380
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SIS04400

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      END
      SUBROUTINE SISNL(VOLT,CUR,NOPNTS,IBASE1,CHI,NOCHI,RN,FACTOR,FREQ,
1RID)
C
      REAL VOLT(NOPNTS), CHI(NOCHI), CUR(NOPNTS)
      COMPLEX UTERM(1024), FACTOR(NOPNTS), CVOL(128), CSUM, CTEMP
      COMPLEX CCHI(1024)
      DATA PI,E,HBAR/3.1415926,1.602E-19,1.055E-34/
C
      THIS IS THE SIS NONLINEAR NETWORK CALCULATION SUBROUTINE
      SUBROUTINE PART OF THE MULTIPLE REFLECTION TECHNIQUE
C
      ITST1 = 10
      IF(NOCHI.EQ.1024) ITST1 = 11
      ITST2 = -ITST1
C
      IF(NOCHI.GT.1024) GO TO 1000
      IF(NOCHI.NE.1024 .AND. NOCHI.NE.512) GO TO 1002
C
      SET UP A FEW PARAMETERS
C
      OMEGA = 2. * PI * FREQ
      NODIV2 = NOPNTS/2
      INTER = -IBASE1
      CONST = -1. * E / HBAR / OMEGA
      HSTEP = 1. / FREQ / FLOAT(NOPNTS)
C
      CALCULATE THE DC SEPARATELY
C
      DO 100 I = 1,NOPNTS
100  CVOL(I) = VOLT(I)
      CALL FFT(IBASE1,CVOL,FACTOR)
      RAMP = REAL(CVOL(1)) * (-1.) * E / HBAR
C
      INTEGRATE THE NON-DC COMPONENTS
C
      DO 200 I = 2,NODIV2
      ICORR = NOPNTS - I + 2
      CVOL(I) = CVOL(I) / CMPLX(0.,1.) / FLOAT(I-1) * CONST
      CVOL(ICORR) = CONJG(CVOL(I))
200  CONTINUE
      CVOL(1) = CMPLX(0.,0.)
      CVOL(NODIV2+1) = CMPLX(0.,0.)
C
      CALL FFT(INTER,CVOL,FACTOR)
C
      NTIME = NOCHI / NOPNTS + 1
C
      CALCULATE U
C
      NTIME = 2 * NOCHI / NOPNTS
      DO 300 J = 1,NTIME
      DO 300 I = 1,NOPNTS
      IPTR = NOPNTS * (J-1) + I
      TEMP = REAL(CVOL(I)) + FLOAT(IPTR-1) * HSTEP * RAMP

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                IF (ABS(TEMP).LE.2.*PI) GO TO 250
                IREVS = TEMP/2./PI
                TEMP = TEMP - FLOAT(IREVS) * 2. * PI
250           CTEMP = CMPLX(0.,TEMP)
                UTERM(IPTP) = CEXP(CTEMP)
300           CONTINUE
C
                DO 5000 IMF = 1,NOCHI
                CCHI(IMF) = CHI(IMF)
                CCHI(IMF+NOCHI) = 0.0
5000          CONTINUE
C
                DO THE CONVOLUTION CALCULATIONS IN THE FREQUENCY DOMAIN
C
                CALL FFT(ITST1,CCHI,FACTOR)
                CALL FFT(ITST1,UTERM,FACTOR)
C
                NOCHM2 = 2 * NOCHI
                DO 6000 IMF = 1,NOCHM2
                CCHI(IMF) = CCHI(IMF) * UTERM(IMF) * FLOAT(NOCHM2)
6000          CCNTINUE
C
                CALL FFT(ITST2,CCHI,FACTOR)
                CALL FFT(ITST2,UTERM,FACTOR)
C
C
                PERFORM THE FINAL CALCULATIONS AND CORRECT FOR THE
                IDENTITY ELEMENT VALUE
C
                DO 600 I = 1,NOPNTS
                N = 2*NOCHI - NOPNTS + I
                CSUM = CIPLEX(0.,0.)
                N = NOCHI + 1
                NOMIN1 = NOCHI - 1
                NOMIN3 = NOCHI - 3
                DO 500 K = 1,NOMIN3,2
                CSUM = (CHI(K)*UTERM(N-K+1)+4.0*CHI(K+1)*UTERM(N-K)+
                1*CHI(K+2)*UTERM(N-K-1))/3.0 + CSUM
C500          CONTINUE
                CSUM = CSUM+(CHI(NOMIN1)*UTERM(N-NOCHI+2)+4.0*CHI(NOCHI)
                1*UTERM(N-NOCHI+1))/3.0
                CSUM = CCHI(N)
                CSUM = CSUM * CONJG(UTERM(N)) * HSTEP
                CUR(I) = VOLT(I) / RN + AIMAG(CSUM) - VOLT(I) / RID
600          CONTINUE
C
                RETURN
C
1000          WRITE(6,1001) NOCHI
1001          FORMAT(1X,'NOCHI = ',I5,' AND IS TOO BIG FOR THE AVAIL MEMORY')
                STOP
C
1002          WRITE(6,1003) NOCHI
1003          FORMAT(1X,'NOCHI = ',I5,' AND IS AN INCORRECT VALUE')
                STOP
                END

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SUBROUTINE COMPAR(LATEST,OLD,NOPNTS,FREITR)          SIS05510
REAL LATEST(NOPNTS), OLD(NOPNTS)                  SIS05520
LOGICAL FREITR                                     SIS05530
COMMON /PERIPH/IN,IOUT                             SIS05540
COMMON /ERRALL/ TOL, EPS                           SIS05550
C
C AUTHOR: R.G. HICKS, UNIV. OF QLD., APRIL 1977    SIS05560
C
C AIM: THIS SUBROUTINE COMPARES TWO VECTORS 'LATEST' SIS05570
C       AND 'OLD' AND PROVIDES A LOGIC ANSWER 'FREITR' SIS05580
C       AS TO WHETHER THE TWO VECTORS ARE SUFFICIENTLY EQUAL. SIS05590
C
C FREITR = .FALSE.                                  SIS05600
C ERR = 0.0                                          SIS05610
C
C TOP = 0.                                           SIS05620
C DO 5 I = 1,NOPNTS                                  SIS05630
C   IF(ABS(LATEST(I)).GT.TOP) TOP = ABS(LATEST(I))  SIS05640
C   CONTINUE                                         SIS05650
C
C DO 10 I=1,NOPNTS                                   SIS05660
C   IF(ABS(LATEST(I)).LE.EPS*TOP) GO TO 10          SIS05670
C   TEST = (LATEST(I) - OLD(I))/LATEST(I)          SIS05680
C   IF(ABS(TEST).GT.TOL) FREITR = .TRUE.           SIS05690
C   IF(ABS(TEST) .LE. ERR) GO TO 10                SIS05700
C   ERR = ABS(TEST)                                  SIS05710
C   MEM = I                                          SIS05720
C   CONTINUE                                         SIS05730
C
C 10 WRITE(IOUT,20) ERR, MEM                          SIS05740
C 20 FORMAT(8X,'ERP = ',E15.8,' POSN NO = ',I5)      SIS05750
C
C RETURN                                             SIS05760
C END                                                SIS05770
SUBROUTINE TOPS(FREQ,FIF,IBASE2,NOIV,IBASE1,NOPNTS,MMAX,CAP, SIS05780
1RN,TEMP,NHAX,VOLT,Y0,Y1,Y1M,ZLO,IVDAT,J,FACTOR,DELTAV,ISIG,ZSSB) SIS05790
REAL IVDAT(NOIV), VOLT(NOPNTS)                     SIS05800
COMPLEX YSIG(31,31), NOISE(31,31), ZSIG(31,31), ZOUT SIS05810
COMPLEX B(31), STORE(31,31)                         SIS05820
COMPLEX FACTOR(NOIV), Y0, Y1,Y1M, Z0, ZSSB(MMAX)   SIS05830
COMPLEX J(NOIV), W(128)                             SIS05840
COMPLEX YSI2(3,3), NOI2(3,3), ZSI2(3,3)           SIS05850
COMPLEX YCAP, ZLO                                    SIS05860
COMMON /PERIPH/ IN, IOUT, IPLOT                     SIS05870
COMMON /RBOUT/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, RLOSS, RTEMP SIS05880
C
C THIS IS THE MAIN SMALL SIGNAL CONVERSION AND NOISE SIS05890
C CONTROLLING CALCULATION ROUTINE                   SIS05900
C
C WRITE(6,709) VJDC, VJLO                            SIS05910
C 709 FORMAT(1X,'DC VOLTAGE AT THE JUNCTION',8X,'= ',E15.8,' VOLTS'/ SIS05920
C 11X,'LO VOLTAGE (PEAK) AT THE JUNCTION = ',E15.8,' VOLTS') SIS05930
C
C WRITE(6,1)                                          SIS05940
C 1 FORMAT(1X,'SMALL SIGNAL AND NOISE ANALYSIS SECTION') SIS05950

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C          IF(ISIG.EQ.1) GO TO 5500          SIS06060
C          FOR THE GENERAL ANALYSIS METHOD  SIS06070
C          DO 10 I = 1,MMAX                 SIS06080
C          B(I) = CMPLX(0.,0.)              SIS06090
C          DO 10 II = 1,MMAX                SIS06100
C          ZSIG(I,II) = CMPLX(0.,0.)        SIS06110
C          STORE(I,II) = CMPLX(0.,0.)       SIS06120
C          NOISE(I,II) = CMPLX(0.,0.)       SIS06130
C          YSIG(I,II) = CMPLX(0.,0.)        SIS06140
10        CONTINUE                          SIS06150
C          WRITE(6,504)                     SIS06160
504        FORMAT(/1X,'DETERMINING SMALL SIGNAL MIXER PROPERTIES USING',
1         ' THE GENERAL ANALYSIS')          SIS06170
C          CALL SIGNL(IVDAT,NOIV,FREQ,IBASE1,IBASE2,VOLT,NOPNTS,YSIG,MMAX,
1         FIF,DELTAV,J,W,FACTOR,NMAX,RN)    SIS06180
C          CALL SIGLIN(FREQ,YSIG,MMAX,FIF,CAP,ZSSB)  SIS06190
C          CALL INVRT(MMAX,YSIG,ZSIG,B,STORE)      SIS06200
C          CALL LOSCAL(MMAX,YSIG,ZSIG,Y0,Y1,YIM)    SIS06210
C          CALL SISNOI(W,NMAX,MMAX,NOIV,FREQ,FIF,VJDC,
1         1J,DELTAV,TEMP,NOISE,NOPNTS,RN)        SIS06220
C          CALL PESNOI(TEMP,NOISE,MMAX,FREQ,FIF,CAP,ZSSB)
1         CALL PROCES(ZSIG,NOISE,MMAX,Y1,YIM)    SIS06230
C          GO TO 5000                          SIS06240
C          USING THE APPROXIMATE THREE-PORT MODEL  SIS06250
C          DO 15 I = 1,3                       SIS06260
C          DO 15 II = 1,3                       SIS06270
C          NOI2(I,II) = CMPLX(0.,0.)           SIS06280
C          ZSI2(I,II) = CMPLX(0.,0.)          SIS06290
C          YSI2(I,II) = CMPLX(0.,0.)          SIS06300
15        CONTINUE                          SIS06310
C          DO 17 I = 1,MMAX                     SIS06320
C          B(I) = CMPLX(0.,0.)                 SIS06330
C          DO 17 II = 1,MMAX                    SIS06340
C          STORE(I,II) = CMPLX(0.,0.)          SIS06350
17        CONTINUE                          SIS06360
C          WRITE(6,505)                         SIS06370
505        FORMAT(/1X,'THREE PORT SMALL SIGNAL ANALYSIS USING FORMULAE')
1         CALL THEORY(VJLO,VJDC,NMAX,IVDAT,NOIV,J,FREQ,YSI2,NOI2,TEMP,
1         1DELTAV,RN,Y0,Y1,YIM,ZLO)          SIS06380
C          WRITE(6,506)                         SIS06390
4999      WRITE(6,506)                         SIS06400

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506  FORMAT(/1X,'THREE PORT ANALYSIS USING MATRIX TECHNIQUES')      SIS06610
C                                         SIS06620
  CALL SIGLJN(FREQ,YSI2,3,FIF,CAP,ZSSB)      SIS06630
  CALL INVRT(3,YSI2,ZSI2,B,STORE)           SIS06640
  CALL LOSCAL(3,YSI2,ZSI2,Y0,Y1,Y1M)       SIS06650
  CALL RESNOI(TEMP,NOI2,3,FREQ,FIF,CAP,ZSSB) SIS06660
  CALL PROCES(ZSI2,NOI2,3,Y1,Y1M)          SIS06670
C                                         SIS06680
5000  RETURN                               SIS06690
C                                         SIS06700
  END                                       SIS06710
  SUBROUTINE RESNOI(TEMP,NOISE,MMAX,FREQ,FIF,CAP,ZSSB) SIS06720
  REAL K                                     SIS06730
  COMPLEX NOISE(MMAX,MMAX), YPAR, ZSSB(MMAX) SIS06740
  DATA HBAR/1.055E-34/                     SIS06750
  DATA PI/3.1415926/                       SIS06760
  DATA K/1.380622E-23/                     SIS06770
C                                         SIS06780
C  DETERMINE THE THERMAL NOISE COMPONENT EMANATING FROM      SIS06790
C  THE RESISTANCES USING THE QUANTUM CORRECTED FORMULA     SIS06800
C  NO NOISE FROM THE EMBEDDING IMPEDANCES AT THE SIGNAL   SIS06810
C  AND IMAGE IS CONSIDERED IN THE DEFINITION              SIS06820
C                                         SIS06830
C  DO 100 I = 1,MMAX                                       SIS06840
  M = (MMAX/2) - I + 1                                     SIS06850
  IPTR = IABS(M) * 2                                       SIS06860
  IF(M.LE.0) IPTR = IPTR + 1                                 SIS06870
  IF(CABS(ZSSB(IPTR)).LT.1.E-10) GO TO 500                 SIS06880
  YPAR = 1. / ZSSB(IPTR)                                     SIS06890
  GO TO 600                                                 SIS06900
500  YPAR = CMPLX(0.0,1.E10)                                SIS06910
600  IF(IABS(M).EQ.1) YPAR = CMPLX(0.0,0.0)                SIS06920
  IF(M.EQ.0) YPAR = CMPLX(0.0,0.0)                        SIS06930
  OMEGAM = (FLOAT(M) * FREQ + FIF) * 2.0 * PI            SIS06940
  VAL = HBAR * OMEGAM / K / TEMP                           SIS06950
  NOISE(I,I) = NOISE(I,I) + 4.0*HBAR*OMEGAM*REAL(YPAR)   SIS06960
1  / (EXP(VAL) - 1.0)                                       SIS06970
100  CONTINUE                                             SIS06980
  RETURN                                                    SIS06990
  END                                                       SIS07000
  SUBROUTINE PROCES(ZSIG,NOISE,MMAX,Y1,Y1M)               SIS07010
  REAL K                                                   SIS07020
  COMPLEX STORE(31). SUM                                   SIS07030
  COMPLEX Y1, Y1M, NOISE(MMAX,MMAX), ZSIG(MMAX,MMAX)    SIS07040
  COMPLEX ZIN                                             SIS07050
  INTEGER SGPORT                                          SIS07060
  COMMON /R0G01/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, RLOSS, TEMP1 SIS07070
  DATA K/1 380622E-23/, TOL/1.E-4/                      SIS07080
C                                         SIS07090
C  DETERMINE THE NOISE TEMPERATURE USING THE IMPEDANCE     SIS07100
C  MATRIX AND THE NOISE CONTRIBUTIONS MATRIX              SIS07110
C                                         SIS07120
  IFPORT = MMAX/2 + 1                                     SIS07130
  SGPORT = MMAX/2                                         SIS07140
C                                         SIS07150

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DO 20 I = 1,MMAX                                SIS07160
SUM = CMPLX(0.,0.)                               SIS07170
DO 10 J = 1,MMAX                                SIS07180
SUM = SUM + NOISE(I,J) * CONJG(ZSIG(IFPORT,J))   SIS07190
10 CONTINUE                                     SIS07200
STORE(I) = SUM                                  SIS07210
20 CONTINUE                                     SIS07220
C                                                SIS07230
SUM = CMPLX(0.,0.)                               SIS07240
C                                                SIS07250
DO 30 I = 1,MMAX                                SIS07260
SUM = SUM + ZSIG(IFPORT,I) * STORE(I)           SIS07270
30 CONTINUE                                     SIS07280
C                                                SIS07290
VREAL = REAL(SUM)                               SIS07300
VIMAG = AIMAG(SUM)                              SIS07310
IF(ABS(VIMAG).GT.TOL*ABS(VREAL)) GO TO 100      SIS07320
C                                                SIS07330
VAL1 = CAES(ZSIG(IFPORT,SGPORT))                SIS07340
VAL2 = CAES(ZSIG(IFPORT,IFPORT+1))              SIS07350
C                                                SIS07360
POWER = REAL(SUM) / 50.0                        SIS07370
C WRITE(6,50) POWER                              SIS07380
C50 FORMAT(2Y,'IF OUTPUT POWER INTO 50 OHM LOAD = ',E15.8) SIS07390
C                                                SIS07400
TEMP1 = REAL(SUM) / (4.*K*REAL(Y1)*VAL1**2)     SIS07410
TEMP2 = REAL(SUM) / (4.*K*REAL(Y1)*VAL2**2)     SIS07420
WRITE(6,40) TEMP1, TEMP2                        SIS07430
40 FORMAT(/8X,'SSB TEMP OF MIXER (USB) = ',E15.8,' DEG K' / SIS07440
18X,'SSB TEMP OF MIXER (LSB) = ',E15.8,' DEG K') SIS07450
C                                                SIS07460
RETURN                                           SIS07470
C                                                SIS07480
100 WRITE(6,110) VREAL, VIMAG                   SIS07490
110 FORMAT(1X,'PROBLEM IN TEMPERATURE CALCULATIONS: '/ SIS07500
11X,'TEMP = ',E15.8,' +J ',E15.8)              SIS07510
RETURN                                           SIS07520
END                                              SIS07530
SUBROUTINE SIGNL(IVDAT,NOIV,FREQ,IBASE1,IBASE2,VOLT,NOPNTS,YSIG, SIS07540
IMMAX,FIF,DELTA V,J,W,FACTOR,NMAX,RN)          SIS07550
REAL IVDAT(NOIV), VOLT(NOPNTS)                 SIS07560
COMPLEX CVOL(128), J(NOIV), W(NOPNTS), YSIG(MMAX,MMAX) SIS07570
COMPLEX CVAL1, CVAL2, CVAL3, CVAL4, CSUM       SIS07580
COMPLEX FACTOR(NOIV)                            SIS07590
COMMON /RBOU/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, RLOSS, RTEMP SIS07600
DATA PI,E,HBAR/3.1415926,1.602E-19,1.055E-34/   SIS07610
C                                                SIS07620
C DETERMINE THE ADMITTANCE CONVERSION COMPONENTS DUE TO     SIS07630
C THE SIS TUNNEL JUNCTION AS PER TUCKERS THEORY           SIS07640
C                                                         SIS07650
C OMEGA = 2. * PI * FREQ                               SIS07660
NGDIV2 = NOPNTS/2                                    SIS07670
INTER1 = -IBASE1                                     SIS07680
INTER2 = -IBASE2                                     SIS07690
CONST = -1. * E / HBAP / OMEGA                    SIS07700

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FILE: SISCAP FORTPAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

HSTEP = 1. / FREQ / FLOAT(NOPNTS)
WIF = 2. * PI * FIF
C
DO 100 I = 1,NOPNTS
100 CVOL(I) = VOLT(I)
CALL FFT(IBASE1,CVOL,FACTOR)
C
VBIAS = REAL(CVOL(1))
C
DO 200 I = 2,NODIV2
ICORR = PNTS - I + 2
CVOL(I) = VOL(I) / CMPLX(. ,1.) / FLOAT(I-1) * CONST
CVOL(ICORR) = CONJG(CVOL(I))
200 CONTINUE
C
CVOL(1) = CMPLX(. ,0.)
CVOL(NODIV2+1) = CMPLX(0.,0.)
C
CALL FFT(INTER1,CVOL,FACTOR)
C
DO 300 I = 1,NOPNTS
TEMP = REAL(CVOL(I))
CVOL(I) = CMPLX(0.,TEMP)
W(I) = CEXP(CVOL(I))
300 CONTINUE
C
CALL FFT(IBASE1,W,FACTOR)
C
VNORM = E * VBIAS / HBAR
C
DO 1000 M1 = 1,MMAX
DO 1000 M2 = 1,MMAX
M = MMAX/2 - M1 + 1
MDASH = MMAX/2 - M2 + 1
IDIF = M - MDASH
WMDASH = FLOAT(MDASH) * OMEGA + WIF
CSUM = CMPLX(0.,0.)
DO 500 N1 = 1,NMAX
NDASH = NMAX/2 - N1 + 1
N = NDASH - IDIF
IF(IABS(N).GT.NMAX/2) GO TO 500
ARG1 = FLOAT(N) * OMEGA + VNORM
ARG2 = FLOAT(N) * OMEGA - WMDASH + VNORM
ARG3 = FLOAT(NDASH) * OMEGA + WMDASH + VNORM
ARG4 = FLOAT(NDASH) * OMEGA + VNORM
CALL EVALJ(ARG1,CVAL1,J,NOIV,DELTAV,RN)
CALL EVALJ(ARG2,CVAL2,J,NOIV,DELTAV,RN)
CALL EVALJ(ARG3,CVAL3,J,NOIV,DELTAV,RN)
CALL EVALJ(ARG4,CVAL4,J,NOIV,DELTAV,RN)
IF(ABS(WMDASH).GT.1.0E9*2.0*PI) GO TO 4356
CALL DERIJ(ARG1,CVAL1,J,NOIV,DELTAV,RN)
CALL DERIJ(ARG4,CVAL4,J,NOIV,DELTAV,RN)
CVAL4 = CMPLX(-1.,0.) * CVAL4
CVAL2 = CMPLX(0.,0.,0.)
CVAL3 = CMPLX(0.,0.,0.)
SIS07710
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SIS07990
SIS08000
SIS08010
SIS08020
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4356 NPTR1 = N + 1                                SIS08260
      IF(IABS(N).GE.NOPNTS/2) GO TO 500           SIS08270
      IF(NPTR1.LE.0) NPTR1 = NPTR1 + NOPNTS      SIS08280
      NPTR2 = NDASH + 1                          SIS08290
      IF(IABS(NDASH).GE.NOPNTS/2) GO TO 500     SIS08300
      IF(NPTR2.LE.0) NPTR2 = NPTR2 + NOPNTS     SIS08310
      CSUM = W(NPTR1) * CONJG(W(NPTR2)) * (CVAL1-CVAL2-CONJG(CVAL3)
500 I + CONJG(CVAL4)) + CSUM                     SIS08320
CONTINUE                                         SIS08330
YSIG(M1,M2) = CMPLX(0.,-1.)*E/2./HBAR/WMDASH*CSUM SIS08340
IF(ABS(WMDASH).GT.1.0E9*2.0*PI) GO TO 1000     SIS08350
YSIG(M1,M2) = CMPLX(0,0,-1.0) / 2.0 * CSUM    SIS08360
C1963 WRITE(6,2P31) M1,M2, YSIG(M1,M2)         SIS08370
C2831 FORMAT(1X,'M1=',I5,'M2=',I5,'YSIG=',2E15.8) SIS08380
1000 CONTINUE                                    SIS08390
      RETURN                                      SIS08400
      END                                         SIS08410
      SUBROUTINE GETJ(IVDAT,NOIV,FREQ,IBASE2,J,FACTOR,RN,DELTA) SIS08420
      COMPLEX CTEMP(2048), FACTOR(NOIV), J(NOIV) SIS08430
      REAL IVDAT(NOIV)                          SIS08440
C                                                SIS08450
C                                                SIS08460
C OBTAIN THE VECTOR J BY PERFORMING A KRONERS KRONIG SIS08470
C TRANSFORM ON THE REDUCED I-V CURVE AS PER THE REPORT SIS08480
C                                                SIS08490
      IBASE3 = IBASE2 + 1                       SIS08500
      NOUSE = 2 * NOIV                          SIS08510
      INTER3 = -IBASE3                          SIS08520
C                                                SIS08530
      DO 100 I = 1,NOIV                         SIS08540
      CTEMP(I) = IVDAT(I)                       SIS08550
      IF(I.EQ.1) GO TO 100                      SIS08560
      ICORR = NOUSE - I + 2                     SIS08570
      CTEMP(ICOPR) = -IVDAT(I)                  SIS08580
100 CONTINUE                                    SIS08590
      CTEMP(NOIV+1) = CMPLX(0.,0.)             SIS08600
C                                                SIS08610
      CALL FFT(IBASE3,CTEMP,FACTOR)             SIS08620
C                                                SIS08630
      DO 200 I = 2,NOIV                         SIS08640
      CTEMP(I) = CMPLX(0.,1.) * CTEMP(I)       SIS08650
      ICORR = NOUSE - I + 2                     SIS08660
      CTEMP(ICORR) = CMPLX(0.,-1.) * CTEMP(ICORR) SIS08670
200 CONTINUE                                    SIS08680
C                                                SIS08690
      CTEMP(1) = CMPLX(0.,0.)                  SIS08700
      CTEMP(NOIV+1) = CMPLX(0.,0.)             SIS08710
C                                                SIS08720
      CALL FFT(INTER3,CTEMP,FACTOR)            SIS08730
C                                                SIS08740
      DIFF = REAL(CTEMP(1))                    SIS08750
C                                                SIS08760
      DO 300 I = 1,NOIV                         SIS08770
      TEMP = REAL(CTEMP(I)) - DIFF              SIS08780
      HOLD = IVDAT(I)                          SIS08790
      J(I) = CMPLX(TEMP,HOLD)                  SIS08800

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300 CONTINUE
C
C RETURN
C
C END
C SUBROUTINE SIGLIN(FREQ,YSIG,MMAX,FIF,CAP,ZSSB)
C COMPLEX YSIG(MMAX,MMAX), ZSSB(MMAX), CVAL
C
C OBTAIN THE CONTRIBUTIONS TO THE SIGNAL CONVERSION MATRIX
C FROM THE EMBEDDING IMPEDANCES
C
C DO 2000 M1 = 1,MMAX
C M = MMAX/2 - M1 + 1
C
C IPTR = IABS(M) * 2
C IF(M.LE.0) IPTR = IPTR + 1
C IF(CABS(ZSSB(IPTR)).LT.1.E-10) GO TO 500
C CVAL = 1. / ZSSB(IPTR)
C GO TO 600
500 CVAL = CMPLX(1.E10,1.E10)
600 YSIG(M1,M1) = YSIG(M1,M1) + CVAL
2000 CONTINUE
C RETURN
C END
C SUBROUTINE LOSCAL(MMAX,YSIG,ZSIG,Y0,Y1,Y1M)
C
C INTEGER SGPORT
C REAL LOSS, LOSSL
C REAL MSMCHI, MSMCHO
C COMPLEX Z11, ZIN, CTMP1, ZSOURC, ZOUT
C COMPLEX Y0,Y1,YSIG(MMAX,MMAX),ZSIG(MMAX,MMAX),Z01, Z00, RHO
C COMPLEX Y1M, Z0M1
C COMMON /REOUT/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, LOSS, RTEMP
C
C CALCULATE THE CONVERSION LOSS FROM THE SMALL SIGNAL
C IMPEDANCE CONVERSION MATRIX
C
C RSOURC = 1.0/REAL(Y1)
C R0 = 1.0 / REAL(Y0)
C
C IFPORT = MMAX/2 + 1
C SGPORT = MMAX/2
C IMPORT = MMAX/2 + 2
C Z01 = ZSIG(IFPORT,SGPORT)
C Z00 = ZSIG(IFPORT,IFPORT)
C Z0M1 = ZSIG(IFPORT,IMPORT)
C Z11 = ZSIG(SGPORT,SGPORT)
C
C ZOUT = 1.0 / (1.0/Z00 - 1.0/R0)
C RHO = (ZOUT - R0) / (ZOUT + R0)
C VSWR = (1.0 + CABS(RHO)) / (1.0 - CABS(RHO))
C WRITE(6,555) ZOUT, R0, VSWR
555 FORMAT(/8X,'IF OUTPUT IMPEDANCE = ',E15.8,' +J ',E15.8/
C 18X,'IF VSWR REFERRED TO ',F5.2,' OHMS = ',E15.8)
C

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SIS08990
SIS09000
SIS09010
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SIS09350

FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

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ZIN = 1.0 / (1.0/Z11 - 1.0/RSOURC)
CTMP1 = RSOURC + ZIN
MSMCHI = 4.0*RSOURC*REAL(ZIN)/(CABS(CTMP1)**2)
DB1 = ABS(MSMCHI)
DB1 = 10.0 * ALOG10(DB1)
IF(MSMCHI.LT.0.0) DB1 = 0.0
C
CTMP1 = R0 + ZOUT
MSMCHO = 4.0*R0*REAL(ZOUT)/(CABS(CTMP1)**2)
DB2 = ABS(MSMCHO)
DB2 = 10.0*ALOG10(DB2)
IF(MSMCHO.LT.0.0) DB2 = 0.0
C
WRITE(6,4000) MSMCHO, DB2, ZIN, MSMCHI, DB1, RSOURC
4000 FORMAT(8X,'OUTPUT MISMATCH GAIN = ',E15.8,' (',E15.8,'DB)')//
18X,'INPUT SIGNAL IMPEDANCE = ',E15.8,' +J ',E15.8,' OHMS'/
28X,'INPUT MISMATCH GAIN = ',E15.8,' (',E15.8,'DB)'/
38X,'INPUT GAIN CALCULATION REFERRED TO = ',E15.8,' OHMS')
C
LOSS = 0.25/CABS(Z01)**2/REAL(Y1)/REAL(Y0)
LOSS = -10. * ALOG10(LOSS)
LOSSL = 0.25/CABS(Z0M1)**2/REAL(Y1M)/REAL(Y0)
LOSSL = -10.0 * ALOG10(LOSSL)
WRITE(6,3000) LOSS, LOSSL
3000 FORMAT(/8X,'CONVERSION GAIN (USB) EQUALS ',E15.8,' DB'/
18X,'CONVERSION GAIN (LSB) EQUALS ',E15.8,' DB')
RETURN
END
SUBROUTINE EVALJ(DUM,CVAL,J,NOIV,DELTAV,RN)
COMPLEX CVAL, J(NOIV), TERP, TERP2, TERP3, TERP5
LOGICAL FLAG
DATA E, HBAR/1.602E-19,1.055E-34/
C
C EVALUATE THE REQUIRED VALUE OF J BY INTERPOLATING
C THROUGH THE ARRAY OF CALCULATED J VALUES.
C FOR NEGATIVE ARGUMENTS, THE CONJUGATE VALUE OF J
C MUST BE USED.
C
FLAG = .FALSE.
ARG = DUM
IF(ARG) 100,400,300
100 FLAG = .TRUE.
ARG = -DUM
300 PTR = ARG / DELTAV / E * HBAR
IPTR = PTR + 1.
IF(IPTR.GE.NOIV-1) GO TO 200
RATIO = A10D(PTR,1.)
CVAL = TERP5(J,NOIV,IPTR,RATIO,.FALSE.)
TEMP = PTR * DELTAV / RN
CVAL = CV/L + CMPLX(0.,TEMP)
IF(FLAG)CVAL = CONJG(CVAL)
RETURN
200 TEMP = PTR * DELTAV / RN
CVAL = J(NOIV) + CMPLX(0.,TEMP)
IF(FLAG) CVAL = CONJG(CVAL)

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SIS09360
SIS09370
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SIS09900

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FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

RETURN
400 CVAL = CMPLX(0.,0.)
RETURN
END
SUBROUTINE SISNOI(W,NMAX,MMAX,NOIV,FREQ,FIF,VBIAS,J,DELTAV,
1TEMP,NOISE,NOPNTS,RN)
COMPLEX W(NOPNTS), NOISE(MMAX,MMAX), J(NOIV), CVAL3, CVAL4
DATA PI,E,HBAR/3.1415926,1.602E-19,1.055E-34/
DATA BOLTZ/1.380622E-23/
C
C EVALUATE THE NOISE COMPONENT EMANATING FROM THE
C SHOT NOISE IN THE TUNNEL JUNCTION AS PER TUCKERS
C THEORY.
C
BETA = 1. / BOLTZ / TEMP
OMEGA = 2. * PI * FREQ
WIF = 2. * PI * FIF
CONST = E / HBAR
C
DO 1000 M1 = 1,MMAX
DO 1000 M2 = 1,MMAX
M = MMAX/2 - M1 + 1
MDASH = MMAX/2 - M2 + 1
WMDASH = FLOAT(MDASH) * OMEGA + WIF
IADJ = M - MDASH
DO 500 N1 = 1,MMAX
N = NMAX/2 - N1 + 1
NDASH = N + IADJ
ARG1 = BETA*(E*VBIAS+FLOAT(NDASH)*HBAR*OMEGA+HBAR*WMDASH)/2.
ARG2 = BETA*(E*VBIAS+FLOAT(N)*HBAR*OMEGA-HBAR*WMDASH)/2.
ARG3 = VBIAS+FLOAT(NDASH)*HBAR*OMEGA/E + HBAR*WMDASH/E
ARG4 = VBIAS + FLOAT(N)*HBAR*OMEGA/E - HBAR*WMDASH/E
ARG3 = CONST * ARG3
ARG4 = CONST * ARG4
CALL EVALJ(ARG3,CVAL3,J,NOIV,DELTAV,RN)
CALL EVALJ(ARG4,CVAL4,J,NOIV,DELTAV,RN)
VAL3 = AIMAG(CVAL3)
VAL4 = AIMAG(CVAL4)
VAL1 = COTH(ARG1)
VAL2 = COTH(ARG2)
NPTR1 = N + 1
IF(NPTR1.LE.0) NPTR1 = NPTR1 + NOPNTS
NPTR2 = NDASH + 1
IF(NPTR2.LE.0) NPTR2 = NPTR2 + NOPNTS
NOISE(M1,M2) = NOISE(M1,M2) + E*W(NPTR1)*CONJG(W(NPTR2))*(VAL1
1 * VAL3 + VAL2*VAL4)
500 CONTINUE
1000 CONTINUE
RETURN
END
SUBROUTINE INVRT(NOSIG,YSIG,ZSIG,B,STORE)
C
CCOMPLEX YSIG(NOSIG,NOSIG), ZSIG(NOSIG), B(NOSIG)
COMPLEX STORE(NOSIG,NOSIG)
C

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SIS09910
SIS09920
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SIS09980
SIS09990
SIS10000
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SIS10450

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FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

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COMMON /PERIPH/ IN, IOUT                               SIS10460
C                                                       SIS10470
C THIS ROUTINE INVERTS THE SQUARE MATRIX              SIS10480
C                                                       SIS10490
C   NSQ = NOSIG * NOSIG                                SIS10500
C                                                       SIS10510
C   DO 5 I = 1,NOSIG                                   SIS10520
C   DO 5 J = 1,NOSIG                                   SIS10530
5   STORE(I,J) = YSIG(I,J)                             SIS10540
C                                                       SIS10550
C   CALL FACTOR(STORE,STORE,NOSIG,IFLAG)              SIS10560
C                                                       SIS10570
C   GO TO (20,11),IFLAG                               SIS10580
C                                                       SIS10590
11  WRITE(IOUT,611)                                    SIS10600
611 FORMAT(1X,'THE MATRIX IS SINGULAR')              SIS10610
C   RETURN                                             SIS10620
C                                                       SIS10630
C   DO 21 I = 1,NOSIG                                  SIS10640
21  B(I) = CMPLX(0.,0.)                                SIS10650
C                                                       SIS10660
C   IBEG = 1                                           SIS10670
C   DO 30 J = 1,NOSIG                                  SIS10680
C   B(J) = CMPLX(1.,0.)                                SIS10690
C   CALL SUBST(STORE,B,ZSIG(IBEG),NOSIG)             SIS10700
C   B(J) = 0.                                          SIS10710
30  IBEG = IBEG + NOSIG                               SIS10720
C                                                       SIS10730
C   RETURN                                             SIS10740
C   END                                               SIS10750
C   SUBROUTINE FACTOR(A,W,N,IFLAG)                   SIS10760
C                                                       SIS10770
C   COMPLEX RATIO                                       SIS10780
C   COMPLEX A(N,N), W(N,N)                             SIS10790
C   DATA TOL/1.E-7/                                   SIS10800
C                                                       SIS10810
C   THIS SUBROUTINE FACTORS A GIVEN MATRIX INTO      SIS10820
C   LU FORM USING GAUSSIAN ELIMINATION.              SIS10830
C   SEE CONTE AND DE BOOR: 'ELEMENTARY NUMERICAL    SIS10840
C   ANALYSIS'                                          SIS10850
C   IFLAG = 1                                          SIS10860
C                                                       SIS10870
C   INITIALIZE W                                       SIS10880
C                                                       SIS10890
C   DO 5 I = 1,N                                       SIS10900
C   DO 5 J = 1,N                                       SIS10910
5   W(I,J) = A(I,J)                                    SIS10920
C                                                       SIS10930
C   GAUSS ELIMINATION WITH SCALED PARTIAL PIVOTING  SIS10940
C                                                       SIS10950
C   NMIN1 = N - 1                                       SIS10960
C   DO 100 I = 1,NMIN1                                  SIS10970
C   IF(CABS(W(I,1)).LT.TOL) GO TO 999                 SIS10980
C                                                       SIS10990
C   IPLU1 = I + 1                                       SIS11000

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```

DO 80 J = IPLU1,N
W(J,I) = W(J,I) / W(I,I)
RATIO = -W(J,I)
DO 40 K = IPLU1,N
W(J,K) = W(J,K) + RATIO * W(I,K)
40 CONTINUE
80 CONTINUE
100 CONTINUE
RETURN
C
999 IFLAG = 2
RETURN
END
SUBROUTINE SUBST(W,B,X,N)
C
C COMPLEX SUM
C COMPLEX W(N,N), B(N), X(N)
C
C THIS SUBROUTINE SOLVES THE MATRIX EQUATION AX=B
C WITH A IN LU FORM. SEE CONTE AND DE BOOR:
C 'ELEMENTARY NUMERICAL ANALYSIS'
C
IF(N.GT.1) GO TO 10
X(1) = B(1) / W(1,1)
RETURN
C
10 X(1) = B(1)
DO 15 K = 2,N
KM1 = K - 1
SUM = 0.
DO 14 J = 1,KM1
14 SUM = W(K,J)*X(J) + SUM
15 X(K) = B(K) - SUM
C
X(N) = X(N) / W(N,N)
K = N
DO 20 NP1MK = 2,N
KP1 = K
K = K - 1
SUM = 0.
DO 19 J = KP1,N
19 SUM = W(K,J) * X(J) + SUM
20 X(K) = (X(K) - SUM) / W(K,K)
C
RETURN
END
SUBROUTINE FFT(NUMBER,DATA,FACTOR)
INTEGER CRPSZE, POSN, POINTR, ELMTNO, FACPTR, ABSNUM
INTEGER GRPTR
LOGICAL INVERT
COMPLEX TEMP,W,FACTOR(NUMBER),DATA(NUMBER),WSCALE,TEMP1,
1TEMP2
DATA PI/3.1415926/
C
C AUTHCR. R.G. HICKS, UNIV. OF QLD., APRIL 1977.

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SIS11010
SIS11020
SIS11030
SIS11040
SIS11050
SIS11060
SIS11070
SIS11080
SIS11090
SIS11100
SIS11110
SIS11120
SIS11130
SIS11140
SIS11150
SIS11160
SIS11170
SIS11180
SIS11190
SIS11200
SIS11210
SIS11220
SIS11230
SIS11240
SIS11250
SIS11260
SIS11270
SIS11280
SIS11290
SIS11300
SIS11310
SIS11320
SIS11330
SIS11340
SIS11350
SIS11360
SIS11370
SIS11380
SIS11390
SIS11400
SIS11410
SIS11420
SIS11430
SIS11440
SIS11450
SIS11460
SIS11470
SIS11480
SIS11490
SIS11500
SIS11510
SIS11520
SIS11530
SIS11540
SIS11550

FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

NOGRP = NOGRP * 2
IF (GRPSIZE .GT. 1) GO TO 25
C
DO 70 POSN = 1, N
IPOSN = POSN - 1
CALL JUXTA(N, IPOSN, JUXPOS)
JUXPOS = JUXPOS + 1
IF (JUXPOS.LT.POSN) GO TO 70
TEMP = DATA(POSN)
DATA(POSN) = DATA(JUXPOS)
DATA(JUXPOS) = TEMP
70 CONTINUE
C
IF (INVERT) RETURN
DO 80 POSN = 1, N
TEMP = CONJG(DATA(POSN))
80 DATA(POSN) = TEMP / N
C
RETURN
END
SUBROUTINE JUXTA(N, IPOSN, JUXPOS)
NN = N
NUM = IPOSN
JUXPOS = 0
C
DO 10 I=1, N
NN = NN/2
MEM = NUM
NUM = NUM/2
IREM = MEM - 2*NUM
JUXPOS = 2*JUXPOS + IREM
IF (NN.EQ.1) GO TO 20
10 CONTINUE
20 RETURN
END
SUBROUTINE FACNO(IPOSN, N, ITERNO, FACPTR)
INTEGER FACPTR
C
C THIS ROUTINE IS PART OF THE BUTTERFLY CALCULATION
C PROCEDURE IN PERFORMING A FAST FOURIER TRANSFORM
C
FACPTR = 0
IDIV = N/(2**ITERNO)
ITEMP = IPOSN
ITEMP = ITEMP/IDIV
MUL = N/2
DO 10 I=1, ITERNO
IPEM = ITEMP - ITEMP/2*2
FACPTR = IREM*MUL + FACPTR
ITEMP = ITEMP/2
MUL = MUL/2
10 CONTINUE
RETURN
END
SUBROUTINE ZERO(POINTS, NUMBER)
SIS12110
SIS12120
SIS12130
SIS12140
SIS12150
SIS12160
SIS12170
SIS12180
SIS12190
SIS12200
SIS12210
SIS12220
SIS12230
SIS12240
SIS12250
SIS12260
SIS12270
SIS12280
SIS12290
SIS12300
SIS12310
SIS12320
SIS12330
SIS12340
SIS12350
SIS12360
SIS12370
SIS12380
SIS12390
SIS12400
SIS12410
SIS12420
SIS12430
SIS12440
SIS12450
SIS12460
SIS12470
SIS12480
SIS12490
SIS12500
SIS12510
SIS12520
SIS12530
SIS12540
SIS12550
SIS12560
SIS12570
SIS12580
SIS12590
SIS12600
SIS12610
SIS12620
SIS12630
SIS12640
SIS12650

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```

COMPLEX POINTS(NUMBER)          SIS12660
REAL MAX                          SIS12670
DATA TOL/1.E-5/                  SIS12680
C                                  SIS12690
C AUTHOR: R.G. HICKS, UNIV. OF QLD., APRIL 1977.  SIS12700
C                                  SIS12710
C AIM: THIS SUBROUTINE AUTOMATICALLY ZEROS ANY  SIS12720
C       QUANTITIES WHICH ARE LESS THAN TOL      SIS12730
C       TIMES THE LARGEST QUANTITY IN THE SECTION. SIS12740
C                                  SIS12750
C                                  SIS12760
C                                  SIS12770
MAX = CABS(POINTS(1))             SIS12780
DO 5 J=2,NUMBER                   SIS12790
IF(MAX.LT.CABS(POINTS(J))) MAX = CABS(POINTS(J))
CONTINUE                          SIS12800
5                                  SIS12810
C                                  SIS12820
DO 10 J = 1,NUMBER                SIS12830
IF(CABS(POINTS(J)).LT.TOL*MAX) POINTS(J) = 0.0
CONTINUE                          SIS12840
10                                 SIS12850
C                                  SIS12860
RETURN                             SIS12870
END                                 SIS12880
SUBROUTINE THEORY(VLO,VBIAS,NMAX,IVDAT,NOIV,J,FREQ,YSIG,
INCISE.TEMP,DELTA V,RN,Y0,Y1,Y1M,ZLO)
C                                  SIS12890
C                                  SIS12900
REAL IVDAT(NOIV), VAL(41)         SIS12910
COMPLEX J(NOIV), YSIG(3,3), NOISE(3,3), CVAL1, CVAL2
COMPLEX Y0, Y1,Y1M, ZLO, YLO     SIS12920
COMMON /REOUT/ VX, VY, VJDC, VJLO, CURDC, CURPMP, RLOSS, RTEMP
DATA E,PI,HBAR/1.602E-19,3.1415926,1.055E-34/
DATA BOLTZ, TOL /1.380622E-23,1.E-5/
C                                  SIS12930
C                                  SIS12940
C THIS SUBROUTINE SETS UP THE VALUES FOR CALCULATION
C OF THE SIGNAL CONVERSION AND NOISE TEMPERATURE FOR THE
C THREE FREQUENCY APPROXIMATION
C                                  SIS12950
C                                  SIS12960
OMEGA = 2. * PI * FREQ            SIS12970
ALPHA = E * VLO / HBAR / OMEGA   SIS12980
C                                  SIS12990
C                                  SIS13000
WRITE(6,111) VBIAS, VLO, ALPHA   SIS13010
111 FORMAT(1X,'VBIAS = ',E15.8,1X,'VLO = ',E15.8,
11X,'ALPHA = ',E15.8)            SIS13020
C                                  SIS13030
C                                  SIS13040
NMPL4 = NMAX + 10                 SIS13050
NREQ = NMPL4/2 + 1                SIS13060
C                                  SIS13070
C                                  SIS13080
DO 100 I = 1,NREQ                 SIS13090
N = NREQ - I                       SIS13100
CALL BESJ(ALPHA,N,VAL(I),TOL,IER)  SIS13110
IF(IER.GT.0) GO TO 150             SIS13120
ICORR = NMPL4 - I + 1             SIS13130
VAL(ICORR) = VAL(I)               SIS13140
IF(N/2*2.EQ.N) GO TO 100          SIS13150
VAL(ICORR) = -VAL(I)              SIS13160
100 CONTINUE                       SIS13170
C                                  SIS13180
C                                  SIS13190
C                                  SIS13200

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C		SIS13210
	GO TO 200	SIS13220
C		SIS13230
150	WRITE(6,160)	SIS13240
160	FORMAT(1X,'PROBLEM IN EVALUATING THE BESSEL FUNCTION')	SIS13250
	STOP	SIS13260
C		SIS13270
200	CONST = HBAR * OMEGA / E	SIS13280
C		SIS13290
	GSUM00 = 0.	SIS13300
	GSUM10 = 0.	SIS13310
	GSUM01 = 0.	SIS13320
	GSUM11 = 0.	SIS13330
	GSUM1M = 0.	SIS13340
C		SIS13350
	BSUM00 = 0.	SIS13360
	BSUM10 = 0.	SIS13370
	BSUM01 = 0.	SIS13380
	BSUM11 = 0.	SIS13390
	BSUM1M = 0.	SIS13400
C		SIS13410
	H00 = 0.	SIS13420
	H10 = 0.	SIS13430
	H01 = 0.	SIS13440
	H11 = 0.	SIS13450
	H1M = 0.	SIS13460
C		SIS13470
	ARG = VBIAS	SIS13480
	ARG1 = ARG * E / HBAR	SIS13490
	CALL EVALJ(ARG1,CVAL1,J,NOIV,DELTAV,RN)	SIS13500
	CURDC = AIMAG(CVAL1)	SIS13510
C		SIS13520
	CURPMP = 0.0	SIS13530
	CURLO1 = 0.0	SIS13540
	CURLO2 = 0.0	SIS13550
	CURLO3 = 0.0	SIS13560
	CURLO4 = 0.0	SIS13570
	CURLO5 = 0.0	SIS13580
	CURLO6 = 0.0	SIS13590
	CURLO7 = 0.0	SIS13600
	CURLO8 = 0.0	SIS13610
	CURLO9 = 0.0	SIS13620
	CURLO0 = 0.0	SIS13630
C		SIS13640
	DO 300 I = 1,NMAX	SIS13650
C		SIS13660
	N = NMAX/2 - I + 1	SIS13670
	ARG = VBIAS + FLOAT(N) * CONST	SIS13680
	ARG1 = ARG * E / HBAR	SIS13690
	CALL EVALJ(ARG1,CVAL1,J,NOIV,DELTAV,RN)	SIS13700
	CALL DERIJ(ARG1,CVAL2,J,NOIV,DELTAV,RN)	SIS13710
	TMP1 = AIMAG(CVAL1)	SIS13720
	TMP2 = REAL(CVAL1)	SIS13730
	TMP3 = AIMAG(CVAL2)	SIS13740
	TMP4 = REAL(CVAL2)	SIS13750

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```

C
NPTR = NREQ - N
C
CURPMP = VAL(NPTR)**2 * TMP1 + CURPMP
CURLO1 = VAL(NPTR)*(VAL(NPTR-1)+VAL(NPTR+1))*TMP1 + CURLO1
CURLO2 = VAL(NPTR)*(VAL(NPTR-1)-VAL(NPTR+1))*TMP2 + CURLO2
CURLO3 = VAL(NPTR)*(VAL(NPTR-2)+VAL(NPTR+2))*TMP1 + CURLO3
CURLO4 = VAL(NPTR)*(VAL(NPTR-2)-VAL(NPTR+2))*TMP2 + CURLO4
CURLO5 = VAL(NPTR)*(VAL(NPTR-3)+VAL(NPTR+3))*TMP1 + CURLO5
CURLO6 = VAL(NPTR)*(VAL(NPTR-3)-VAL(NPTR+3))*TMP2 + CURLO6
CURLO7 = VAL(NPTR)*(VAL(NPTR-4)+VAL(NPTR+4))*TMP1 + CURLO7
CURLO8 = VAL(NPTR)*(VAL(NPTR-4)-VAL(NPTR+4))*TMP2 + CURLO8
CURLO9 = VAL(NPTR)*(VAL(NPTR-5)+VAL(NPTR+5))*TMP1 + CURLO9
CURLO0 = VAL(NPTR)*(VAL(NPTR-5)-VAL(NPTR+5))*TMP2 + CURLO0
C
GSUM00 = VAL(NPTR)**2 * TMP3 + GSUM00
GSUM10 = VAL(NPTR) * (VAL(NPTR+1)+VAL(NPTR-1))*TMP3 + GSUM10
GSUM01 = VAL(NPTR)*(VAL(NPTR+1)-VAL(NPTR-1))*TMP1+GSUM01
GSUM11 = ((VAL(NPTR+1))**2 - (VAL(NPTR-1))**2)*TMP1 + GSUM11
GSUM1M = VAL(NPTR)*(VAL(NPTR+2)-VAL(NPTR-2))*TMP1 + GSUM1M
C
BSUM10 = VAL(NPTR)*(VAL(NPTR+1)-VAL(NPTR-1)) * TMP4 + BSUM10
BSUM11 = ((VAL(NPTR+1))**2 - 2.*(VAL(NPTR))**2 +
1 (VAL(NPTR-1))**2) * TMP2 + BSUM11
BSUM1M = (VAL(NPTR+2)*VAL(NPTR)-2.*VAL(NPTR+1)*VAL(NPTR-1) +
1 VAL(NPTR)*VAL(NPTR-2))*TMP2 + BSUM1M
C
APG = ARG * E / 2. / BOLTZ / TEMP
STO = COTH(ARG)
C
H00 = (VAL(NPTR))**2 * STO * TMP1 + H00
H10 = VAL(NPTR) * (VAL(NPTR+1) + VAL(NPTR-1)) * STO * TMP1
1 + H10
H11 = ((VAL(NPTR+1))**2 + (VAL(NPTR-1))**2) * STO * TMP1 + H11
H1M = VAL(NPTR+1) * VAL(NPTR-1) * STO * TMP1 + H1M
300 CONTINUE
C
GSUM10 = 0.5 * GSUM10
GSUM01 = GSUM01 * E / HBAR / OMEGA
GSUM11 = GSUM11 * E / HBAR / OMEGA * 0.5
GSUM1M = GSUM1M * E / HBAR / OMEGA * 0.5
BSUM10 = BSUM10 * 0.5
BSUM11 = BSUM11 * E / HBAR / OMEGA / 2.
BSUM1M = BSUM1M * E / HBAR / OMEGA / 2.
H00 = H00 * 2. * E
H10 = H10 * E
H11 = H11 * E
H1M = H1M * 2. * E
C
GSOURC = REAL(Y1)
BSOURC = AIMAG(Y1)
GIMAGE = PEAL(Y1M)
BIMAGE = AIMAG(Y1M)
GLOAD = REAL(Y0)
BLOAD = AIMAG(Y0)

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SIS13760
SIS13770
SIS13780
SIS13790
SIS13800
SIS13810
SIS13820
SIS13830
SIS13840
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SIS13870
SIS13880
SIS13890
SIS13900
SIS13910
SIS13920
SIS13930
SIS13940
SIS13950
SIS13960
SIS13970
SIS13980
SIS13990
SIS14000
SIS14010
SIS14020
SIS14030
SIS14040
SIS14050
SIS14060
SIS14070
SIS14080
SIS14090
SIS14100
SIS14110
SIS14120
SIS14130
SIS14140
SIS14150
SIS14160
SIS14170
SIS14180
SIS14190
SIS14200
SIS14210
SIS14220
SIS14230
SIS14240
SIS14250
SIS14260
SIS14270
SIS14280
SIS14290
SIS14300

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```

      YLO = CMPLX(1.0,0.0) / ZLO
      GPUMP = REAL(YLO)
      BPUMP = AIMAG(YLO)
      PLO = ((CURL01+GPUMP*VLO)**2+(CURL02-BPUMP*VLO)**2)/8./GPUMP
      WRITE(6,400) PLO
400  FORMAT(/1X,'LOCAL OSCILLATOR POWER = ',E15.8,' WATTS PER JN'/)
C
      CALL GEN3PT(GSUM00,GSUM10,GSUM01,GSUM11,GSUM1M,BSUM10,
1BSUM11,BSUM1M,H00,H10,H11,H1M,GSOURC,GLOAD,BSOURC,GIMAGE,BIMAGE,
1BLOAD)
C
      YSIG(1,1) = CMPLX(GSUM11,BSUM11)
      YSIG(1,2) = CMPLX(GSUM10,BSUM10)
      YSIG(1,3) = CMPLX(GSUM1M,BSUM1M)
      YSIG(2,1) = CMPLX(GSUM01,0.)
      YSIG(2,2) = CMPLX(GSUM00,0.)
      YSIG(2,3) = CMPLX(GSUM01,0.)
      YSIG(3,1) = CMPLX(GSUM1M,-BSUM1M)
      YSIG(3,2) = CMPLX(GSUM10,-BSUM10)
      YSIG(3,3) = CMPLX(GSUM11,-BSUM11)
C
C2832  WRITE(6,2832) ((MK,ML,YSIG(MK,ML),ML=1,3),MK=1,3)
      FORMAT(1X,'MK=',I5,'ML=',I5,'YSIG=',2E15.8)
C
      NOISE(1,1) = CMPLX(H11,0.)
      NOISE(1,2) = CMPLX(H10,0.)
      NOISE(1,3) = CMPLX(H1M,0.)
      NOISE(2,1) = CMPLX(H10,0.)
      NOISE(2,2) = CMPLX(H00,0.)
      NOISE(2,3) = CMPLX(H10,0.)
      NOISE(3,1) = CMPLX(H1M,0.)
      NOISE(3,2) = CMPLX(H10,0.)
      NOISE(3,3) = CMPLX(H11,0.)
C
      RETURN
      END
      SUBROUTINE DERIJ(DUM,CVAL,J,NOIV,DELTAV,RN)
      COMPLEX CVAL, J(NOIV), TERP5
      LOGICAL FLAG
      DATA E,HBAR/1.602E-19,1.055E-34/
C
C      THIS SUBROUTINE EVALUATES THE DERIVATIVE
C      OF J BY INTERPOLATING AMONGST A VECTOR OF J VALUES
C
      CONST = 1. / RN
      FLAG = .FALSE.
      ARG = DUM
      IF(ARG) 100,400,300
100  FLAG = .TRUE.
      ARG = -DUM
300  PTR = ARG / DELTAV / E * HBAR
      IPTR = PTR + 1.
      IF(IPTR.GE.NOIV-1) GO TO 200
      RATIO = A:OD(PTR,1.)
      CVAL = TERP5(J,NOIV,IPTR,RATIO,.TRUE.)/DELTAV + CMPLX(0.,CONST)
      IF(FLAG) CVAL = -1. * CONJG(CVAL)

```

SIS14310
SIS14320
SIS14330
SIS14340
SIS14350
SIS14360
SIS14370
SIS14380
SIS14390
SIS14400
SIS14410
SIS14420
SIS14430
SIS14440
SIS14450
SIS14460
SIS14470
SIS14480
SIS14490
SIS14500
SIS14510
SIS14520
SIS14530
SIS14540
SIS14550
SIS14560
SIS14570
SIS14580
SIS14590
SIS14600
SIS14610
SIS14620
SIS14630
SIS14640
SIS14650
SIS14660
SIS14670
SIS14680
SIS14690
SIS14700
SIS14710
SIS14720
SIS14730
SIS14740
SIS14750
SIS14760
SIS14770
SIS14780
SIS14790
SIS14800
SIS14810
SIS14820
SIS14830
SIS14840
SIS14850

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	RETURN	SIS15410
20	IF(X)30,300,31	SIS15420
30	IER=2	SIS15430
	RETURN	SIS15440
300	BJPPP = 0.0E0	SIS15450
	IF(N.EQ.0) BJPPP = 1.0E0	SIS15460
	IER = 0	SIS15470
	RETURN	SIS15480
31	IF(X-15.D0)32,32,34	SIS15490
32	NTEST=20.D0+10.D0*X-X** 2.D0/3.D0	SIS15500
	GOTO 36	SIS15510
34	NTEST=90.D0+X/2.D0	SIS15520
36	IF(N-NTEST)40,38,38	SIS15530
38	IER=4	SIS15540
	RETURN	SIS15550
40	IER=0	SIS15560
	N1=N+1	SIS15570
	BPREV=0.0D0	SIS15580
C		SIS15590
C	COMPUTE STARTING VALUE OF M	SIS15600
C		SIS15610
	IF(X-5.D0)50,60,60	SIS15620
50	MA=X+6.D0	SIS15630
	GOTO 70	SIS15640
60	MA=1.4D0*X+60.D0/X	SIS15650
70	MB=N+IDINT(X)/4+2	SIS15660
	MZERO=MAX0(MA,MB)	SIS15670
C		SIS15680
C	SET UPPER LIMIT OF M	SIS15690
C		SIS15700
	MMAX=NTEST	SIS15710
100	DO 190 M=MZERO,MMAX,3	SIS15720
C		SIS15730
C	SET F(M),F(M-1)	SIS15740
C		SIS15750
	FM1=1.0D-28	SIS15760
	FM=0.0D0	SIS15770
	ALPHA=0.0D0	SIS15780
	IF(M-(M/2)*2)120,110,120	SIS15790
110	JT=-1	SIS15800
	GO TO 130	SIS15810
120	JT=1	SIS15820
130	M2=M-2	SIS15830
	DO 160 K=1,M2	SIS15840
	MK=M-K	SIS15850
	BMK=2.D0*DFLOAT(MK)*(FM1/X)-FM	SIS15860
	FM=FM1	SIS15870
	FM1=BMK	SIS15880
	IF(MK-N-1)150,140,150	SIS15890
140	PJ=BMK	SIS15900
150	JT=-JT	SIS15910
	S=1+JT	SIS15920
160	ALPHA=ALPHA+BMK*S	SIS15930
	BMK=2.0D0*FM1/X-FM	SIS15940
	IF(N)180,170,180	SIS15950

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```

170 BJ=BMK SIS15960
180 ALPHA=ALPHA+BMK SIS15970
    BJ=BJ/ALPHA SIS15980
    IF(DABS(BJ-BPREV)-DABS(D*BJ))200,200,190 SIS15990
190 BPREV=BJ SIS16000
    IER=3 SIS16010
200 BJPPP = BJ SIS16020
    RETURN SIS16030
    END SIS16040
    FUNCTION COTH(ARG) SIS16050
    REAL NUM, NEG SIS16060
    NEG = -ARG SIS16070
    NUM = EXP(ARG) + EXP(NEG) SIS16080
    DEN = EXP(ARG) - EXP(NEG) SIS16090
    IF(ABS(DEN).LT.1.E-5) GO TO 10 SIS16100
    COTH = NUM / DEN SIS16110
    RETURN SIS16120
10 COTH = 1.E10 SIS16130
    RETURN SIS16140
    END SIS16150
    SUBROUTINE GEN3PT(GSUM00,GSUM10,GSUM01,GSUM11,GSUM1M, SIS16160
1BSUM10,BSUM11,BSUM1M,H00,H10,H11,H1M,GSOURC,GLOAD,BSOURC, SIS16170
2GIMAGE,BIMAGE,BLOAD) SIS16180
    COMMON /REOUT/ VDC, VLO, VJDC, VJLO, CURDC, CURPMP, LOSS, CREAL SIS16190
C SIS16200
    REAL L0, LOSS SIS16210
    COMPLEX LAM01, CTM SIS16220
    COMPLEX Z01, LAM01M SIS16230
    DATA TOL/1.E-5/, BOLTZ/1.380622E-23/ SIS16240
C SIS16250
C THIS SUBROUTINE CALCULATES THE SMALL SIGNAL AND SIS16260
C NOISE PARAMETERS USING THE VALUES THAT HAVE BEEN SIS16270
C SET UP USING SUBROUTINE 'THEORY' SIS16280
C SIS16290
L0 = 2. * GSUM10 / GSUM01 SIS16300
CSI = (GSUM11 - GSUM1M)/(GSUM11 + GSUM1M) SIS16310
GAMMA = BSUM1M / (GSUM11 + GSUM1M) SIS16320
ETA = 2. * GSUM01 * GSUM10 / GSUM00 / (GSUM11 + GSUM1M) SIS16330
GL = GLOAD / GSUM00 SIS16340
BETA = BSUM10 / GSUM10 SIS16350
BI = BIMAGE / (GSUM11 + GSUM1M) SIS16360
GA = (GSOURC + GIMAGE) / 2.0 / (GSUM11 + GSUM1M) SIS16370
GD = (GSOURC - GIMAGE) / 2.0 / (GSUM11 + GSUM1M) SIS16380
BA = (BSUM11 + (BSOURC + BIMAGE) / 2.0) / (GSUM11 + GSUM1M) SIS16390
BD = (BSOURC - BIMAGE) / 2.0 / (GSUM11 + GSUM1M) SIS16400
BL = BLOAD / GSUM00 SIS16410
C SIS16420
    TERM1 = ((CSI + GA) * (1.0 + GA) + (BA**2 - GAMMA**2) - SIS16430
1GD**2 - BD**2) * (1.0 + GL + BL) SIS16440
    TERM2 = (ED * (1.0 + CSI + 2.0*GA) - 2.0*GD*BA) * SIS16450
1(1.0 + GL + BL) SIS16460
    TERM3 = -1.0 * ETA * (CSI + GA + BETA*BA - BETA*GAMMA) SIS16470
    TERM4 = -1.0 * ETA * (BD - BETA * GD) SIS16480
    TERM5 = GSUM00 * (GSUM11 + GSUM1M) **2 SIS16490
    TERM6 = -1.0 * GSUM01 * (GSUM11+GSUM1M) * (CSI + GA - GD) SIS16500

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TERM7 = -1.0 * GSUM01 * (GSUM11+GSUM1M) * (GAMMA + BD - BA)      SIS16510
ZR1 = TERM5 * (TERM1 + TERM3)                                       SIS16520
Z11 = TERM5 * (TERM2 + TERM4)                                       SIS16530
ZR2 = TERM6                                                         SIS16540
Z12 = TERM7                                                         SIS16550
Z01 = CMPLX(ZR2,ZI2) / CMPLX(ZR1,ZI1)                               SIS16560
LOSS = 1./4./GSOURC/GLOAD/CABS(Z01)**2                             SIS16570
LOSS = 10. * ALOG10(LOSS)                                          SIS16580
C                                                                    SIS16590
TERM1 = -GSUM01 * (GSUM11+GSUM1M) * (CSI+GA-GD)                   SIS16600
TERM2 = -GSUM01 * (GSUM11+GSUM1M) * (GAMMA+BD-BA)                 SIS16610
TERM3 = (GSUM11 + GSUM1M) ** 2                                       SIS16620
TERM4 = (CSI+GA) * (1.0+GA) + BA**2 - GAMMA**2 - GD**2 - BD**2    SIS16630
TERM5 = BD * (1.0+CSI+2.0*GA) - 2.0*GD*BA                          SIS16640
TERM6 = TERM3 * TERM4                                               SIS16650
TERM7 = TERM3 * TERM5                                               SIS16660
LAM01 = CMPLX(TERM1,TERM2) / CMPLX(TERM6, TERM7)                   SIS16670
TERM8 = -GSUM01 * (GSUM11+GSUM1M) * (CSI+GA+GD)                   SIS16680
TERM9 = -GSUM01 * (GSUM11+GSUM1M) * (BA+BD-GAMMA)                 SIS16690
LAM01M = CMPLX(TERM8,TERM9) / CMPLX(TERM6,TERM7)                  SIS16700
CTM = (CAES(LAM01M)**2 + CABS(LAM01)**2) * H11                      SIS16710
1 + (LAM01M+CONJG(LAM01M)+CONJG(LAM01)+LAM01) * H10                SIS16720
2 + H00 + (LAM01M*CONJG(LAM01)+LAM01*CONJG(LAM01M))*H1M           SIS16730
CTM = 1./4./GSOURC/CABS(LAM01)**2*CTM/BOLTZ                         SIS16740
CREAL = REAL(CTM)                                                  SIS16750
CIMAG = AIMAG(CTM)                                                SIS16760
IF(CIMAG.GT.TOL*CREAL) GO TO 10000                                  SIS16770
C                                                                    SIS16780
WRITE(6,80) LOSS, CREAL                                           SIS16790
80 FORMAT(1X,'CONVERSION LOSS (USB) = ',E15.8,' DB '/              SIS16800
11X,'SSB SIS MIXER NOISE TEMPERATURE (USB) = ',E15.8,' K')       SIS16810
RETURN                                                             SIS16820
C                                                                    SIS16830
10000 WRITE(6,1001)                                               SIS16840
1001 FORMAT(1X,'PROBLEM DEVELOPED IN TEMPERATURE COMPUTATION')   SIS16850
STOP                                                             SIS16860
END                                                             SIS16870
COMPLEX FUNCTION TERP5(J,NOIV,IPTR,RATIO,FLAG)                     SIS16880
COMPLEX J(NOIV)                                                   SIS16890
COMPLEX STORE(4)                                                 SIS16900
LOGICAL FLAG                                                     SIS16910
DATA N/3/                                                         SIS16920
C                                                                    SIS16930
C THIS COMPLEX VALUED FUNCTION PERFORMS AN INTERPOLATION         SIS16940
C AMONGST THE ARRAY OF J VALUES.                                SIS16950
C IF FLAG IS TRUE, AN INTERPOLATION OF DERIVATIVES IS DONE     SIS16960
C IF FLAG IS FALSE, AN INTERPOLATION OF THE FUNCTION           SIS16970
C J IS DONE.                                                    SIS16980
C THE INTERPOLATING FUNCTION USED IS A+BX+CEXP(DX)              SIS16990
C AND THE APPRAY OF J VALUES MUST BE EVENLY SPACED           SIS17000
C                                                                SIS17010
NP1 = N + 1                                                       SIS17020
MID = (N + 1) / 2                                                 SIS17030
DO 1 K = 1,NP1                                                    SIS17040
KK = IPTR - (MID - 1) + (K-1)                                    SIS17050

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      IF(KK.LE.0) GO TO 2
      STORE(K) = J(KK)
      GO TO 1
2     KK = 2 - KK
      STORE(K) = CONJG(J(KK))
1     CONTINUE
C
      YM1 = REAL(STORE(1))
      Y0 = REAL(STORE(2))
      Y1 = REAL(STORE(3))
      Y2 = REAL(STORE(4))
C
      CURV1 = Y2 - 2.0*Y1 + Y0
      CURV2 = Y1 - 2.0*Y0 + YM1
      IF(CURV1*CURV2 .LT. 0.0) GO TO 470
      IF(ABS(CURV1) .LE. 0.0 .OR. ABS(CURV2) .LE. 0.0) GO TO 470
      D = ALOG(CURV1/CURV2)
      IF(D.EQ.0) GO TO 470
      C = CURV1 / ((EXP(D) - 1.0) ** 2)
      A = Y0 - C
      B = Y1 - A - C*EXP(D)
      VALR = A + B*RATIO + C*EXP(D*RATIO)
      IF(FLAG) VALR = B + C*D*EXP(D*RATIO)
      GO TO 400
C
470  VALR = RATIO * (Y1 - Y0) + Y0
      IF(FLAG) VALR = Y1 - Y0
C
400  YM1 = AIMAG(STORE(1))
      Y0 = AIMAG(STORE(2))
      Y1 = AIMAG(STORE(3))
      Y2 = AIMAG(STORE(4))
C
      CURV1 = Y2 - 2.0*Y1 + Y0
      CURV2 = Y1 - 2.0*Y0 + YM1
      IF(CURV1*CURV2.LT.0.0) GO TO 570
      IF(ABS(CURV1).LE.0.0 .OR. ABS(CURV2).LE.0.0) GO TO 570
      D = ALOG(CURV1/CURV2)
      IF(D.EQ.0) GO TO 570
      C = CURV1 / ((EXP(D) - 1.0) ** 2)
      A = Y0 - C
      B = Y1 - A - C*EXP(D)
      VALI = A + B*RATIO + C*EXP(D*RATIO)
      IF(FLAG) VALI = B + C*D*EXP(D*RATIO)
      GO TO 500
C
570  VALI = RATIO * (Y1 - Y0) + Y0
      IF(FLAG) VALI = Y1 - Y0
C
500  TERP5 = CMPLX(VALR,VALI)
      RETURN
      END
      SUBROUTINE MRT(VOLT,CUR,NOPNTS,IBASE1,CHI,NOCHI,
1     IRN,FACTOR,FREQ,ZIMPED,VSOURC,OLDVOL,FLAG,Z0,NOPER)
C

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SIS17060
 SIS17070
 SIS17080
 SIS17090
 SIS17100
 SIS17110
 SIS17120
 SIS17130
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 SIS17390
 SIS17400
 SIS17410
 SIS17420
 SIS17430
 SIS17440
 SIS17450
 SIS17460
 SIS17470
 SIS17480
 SIS17490
 SIS17500
 SIS17510
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 SIS17530
 SIS17540
 SIS17550
 SIS17560
 SIS17570
 SIS17580
 SIS17590
 SIS17600

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      CALL SISCHA(ESOURC,NOPNTS,Z0,VOLT,CUR,CHI,NOCHI,RN,FREQ,IBASE1,  SIS18160
      INOPER,FACTOR)  SIS18170
C  SIS18180
C  DETERMINES THE REVISED LEFT PROPAGATING WAVE  SIS18190
C  SIS18200
      DO 20 I = 1,NOPNTS  SIS18210
      ELEFT(I) = (VOLT(I) - CUR(I) * Z0) * 0.5  SIS18220
20  CONTINUE  SIS18230
C  SIS18240
      CALL FFT(IBASE1,ELEFT,FACTOR)  SIS18250
C  SIS18260
C  DETERMINE THE REVISED RIGHT PROPAGATING WAVE  SIS18270
C  SIS18280
      DO 30 I = 1,NODIV2  SIS18290
      ICORR = NOPNTS - I + 2  SIS18300
      ERIGHT(I) = (Z0/(ZIMPED(I)+Z0)*VSOURC(I) + RHO(I)*ELEFT(I))*2.0  SIS18310
      IF(I.EQ.1) GO TO 30  SIS18320
      ERIGHT(ICORR) = CONJG(ERIGHT(I))  SIS18330
30  CONTINUE  SIS18340
      ERIGHT(NODIV2 + 1) = CMLX(0.0,0.0)  SIS18350
C  SIS18360
      CALL FFT(INTER,ERIGHT,FACTOR)  SIS18370
      DO 40 I = 1,NOPNTS  SIS18380
      ESOURC(I) = ERIGHT(I) / Z0  SIS18390
40  CONTINUE  SIS18400
C  SIS18410
C  SEE IF A SOLUTION HAS BEEN OBTAINED  SIS18420
C  SIS18430
      CALL COMPAR(VOLT,OLDVOL,NOPNTS,FLAG)  SIS18440
C  SIS18450
      DO 500 JJ = 1,NOPNTS  SIS18460
500  OLDVOL(JJ) = VOLT(JJ)  SIS18470
C  SIS18480
      IF(.NOT.FLAG) GO TO 2000  SIS18490
C  SIS18500
1000  CONTINUE  SIS18510
C  SIS18520
      WRITE(6,1500) NOPER  SIS18530
1500  FORMAT(/8X,'LARGE SIGNAL ANALYSIS DID NOT CONVERGE IN ',I5,'ITNS')  SIS18540
      RETURN  SIS18550
C  SIS18560
2000  WRITE(6,2002) II  SIS18570
2002  FORMAT(/1X,'LARGE SIGNAL ANALYSIS COMPLETED IN ',I5,' ITNS'/)  SIS18580
      RETURN  SIS18590
      END  SIS18600
      SUBROUTINE SISCHA(ESOURC,NOPNTS,RSOURC,VOLT,CUR,CHI,NOCHI,  SIS18610
      1RN,FREQ,IBASE,NOPER,FACTOR)  SIS18620
C  SIS18630
      REAL ESOURC(NOPNTS), VOLT(NOPNTS), CUR(NOPNTS)  SIS18640
      REAL CHI(NOCHI)  SIS18650
      COMPLEX FACTOR(NOPNTS)  SIS18660
      COMMON /REOUT/ VDC,VLO,VJDC,VJLO,CURDC,CURPMP,RLOSS,RTEMP  SIS18670
C  SIS18680
      REAL ZTERM(512), PHASE(512), VOLT2(512)  SIS18690
      COMPLEX UTERM(512), CCUR(128)  SIS18700

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C          SIS18710
C          SET UP PARAMETERS FOR THE CALL TO SUBROUTINE          SIS18720
C          SIS TO DETERMINE THE JUNCTION VOLTAGE AND CURRENT    SIS18730
C          WAVEFORMS                                            SIS18740
C          HDEL = 1.0 / FREQ / FLOAT(NOPNTS)                    SIS18750
C          HDEL = 1.0 / FREQ / FLOAT(NOPNTS)                    SIS18760
C          IADJST = 0                                            SIS18770
C          IADJST = 0                                            SIS18780
C          CALL SIS(CHI,VOLT2,NOPNTS,HDEL,ZTERM,UTERM,          SIS18790
16          1RN,NOCHI,NOPER,PHASE,NOSTOP,IADJST,RSOURC,ESOURC,ISTO) SIS18800
C          DO 1000 I = 1,NOPNTS                                  SIS18810
C          IPNT = (ISTO - 1) * NOPNTS + I - IADJST              SIS18820
C          VOLT(I) = VOLT2(IPNT)                                  SIS18830
C          CUR(I) = ESOURC(I) - VOLT(I) / RSOURC                 SIS18840
C          CCUR(I) = CUR(I)                                      SIS18850
1000      CONTINUE                                             SIS18860
C          CALL FFT(IBASE,CCUR,FACTOR)                           SIS18870
C          CURPMP = CCUR(1)                                      SIS18880
C          CALL FFT(IBASE,CCUR,FACTOR)                           SIS18890
C          CURPMP = CCUR(1)                                      SIS18900
C          RETURN                                               SIS18910
C          END                                                  SIS18920
C          SUBROUTINE SIS(CHI,VOLT,NOPNTS,HDEL,ZTERM,UTERM,     SIS18930
17          1RN,NOCHI,NOPER,PHASE,NOSTOP,IADJST,RSOURC,ESOURC,ISTO) SIS18940
C          INTEGER R, RR, VCNT                                   SIS18950
C          REAL ZTERM(NOCHI), VOLT(NOCHI), CHI(NOCHI), PHASE(NOCHI) SIS18960
C          REAL ESOURC(NOPNTS)                                  SIS18970
C          COMPLEX UTERM(NOCHI), SUM, CDUM, CONST, CSUM, CTEMP  SIS18980
C          LOGICAL FLAG                                         SIS18990
C          DATA HBAR, E/1.055E-34,1.602E-19/                   SIS19000
C          DATA TOL, ITYPE/1.E-5,1/                            SIS19010
C          DATA NHIGH/100/                                       SIS19020
C          DATA VTHRSH/0.0E-3/                                   SIS19030
C          DETERMINE THE SIS TUNNEL JUNCTION CURRENT AND        SIS19040
C          VOLTAGE WAVEFORM COMPONENTS                           SIS19050
C          RNN = 1./(1./RN + 1./RSOURC)                          SIS19060
C          NOSTOP = NOCHI                                         SIS19070
C          UTERM(1) = CMPLX(1.,0.)                                SIS19080
C          VOLT(1) = 0.                                            SIS19090
C          ZTERM(1) = 0.                                           SIS19100
C          PHASE(1) = 0.                                           SIS19110
C          CONST = CMPLX(0.,-1.) * E / HBAR * HDEL              SIS19120
C          DO 1000 I = 1,NOPER                                     SIS19130
C          ISTO = I                                               SIS19140
C          VCNT = 0                                               SIS19150
C          DO 500 RR = 1,NOPNTS                                    SIS19160
C          N = NOPNTS * (I-1) + RR                                SIS19170
C          N = NOPNTS * (I-1) + RR                                SIS19180
C          N = NOPNTS * (I-1) + RR                                SIS19190
C          N = NOPNTS * (I-1) + RR                                SIS19200
C          N = NOPNTS * (I-1) + RR                                SIS19210
C          N = NOPNTS * (I-1) + RR                                SIS19220
C          N = NOPNTS * (I-1) + RR                                SIS19230
C          N = NOPNTS * (I-1) + RR                                SIS19240
C          N = NOPNTS * (I-1) + RR                                SIS19250

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C      IF NECESSARY, SHIFT ALL VALUES LEFT IN THE STORAGE VECTORS      SIS19260
C                                                                              SIS19270
      IF(N.LT.NOCHI) GO TO 658      SIS19280
      DO 657 NPRO = 2,NOCHI      SIS19290
      VOLT(NPRO-1) = VOLT(NPRO)      SIS19300
      PHASE(NPRO-1) = PHASE(NPRO)      SIS19310
      UTERM(NPRO-1) = UTERM(NPRO)      SIS19320
      ZTERM(NPRO-1) = ZTERM(NPRO)      SIS19330
657    CONTINUE      SIS19340
C                                                                              SIS19350
      IADJST = IADJST + 1      SIS19360
C                                                                              SIS19370
C      INITIALLY ESTIMATE THE NEXT VOLTAGE POINT BY      SIS19380
C      ASSUMING A CONSTANT VOLTAGE      SIS19390
C                                                                              SIS19400
658    VOLT(N-IADJST+1) = VOLT(N-IADJST)      SIS19410
      PHASE(N-IADJST+1) = PHASE(N-IADJST) + AIMAG(CONST) *      SIS19420
      1VOLT(N-IADJST+1)      SIS19430
      CALL FIXPHA(PHASE(N-IADJST+1))      SIS19440
      CTEMP = CMPLX(0.,PHASE(N-IADJST+1))      SIS19450
      UTERM(N-IADJST+1) = CEXP(CTEMP)      SIS19460
      VPREV = VOLT(N-IADJST+1)      SIS19470
      VMID1 = VOLT(N-IADJST+1)      SIS19480
      VMID2 = VOLT(N-IADJST+1)      SIS19490
C                                                                              SIS19500
      CSUM = CMPLX(0.,0.)      SIS19510
C                                                                              SIS19520
C      ITERATE TO DETERMINE THE CORRECT VOLTAGE      SIS19530
C      AT THE NEXT POINT IN TIME      SIS19540
C                                                                              SIS19550
      DO 425 MM = 1,NHIGH      SIS19560
C                                                                              SIS19570
      SUM = CMPLX(0.,0.)      SIS19580
C                                                                              SIS19590
      IF(MM.NE.1 .OP. N.EQ.1) GO TO 243      SIS19600
C                                                                              SIS19610
      PERFORM THE REQUIRED CONVOLUTION      SIS19620
C                                                                              SIS19630
      NMIN1 = N - 1      SIS19640
      ITPRY = IADJST + 1      SIS19650
      DO 100 R = ITPRY,NMIN1      SIS19660
      CSUM = (CHI(N-R+1)*UTERM(R-IADJST+1) + CHI(N-R+2)*UTERM(R-IADJST))      SIS19670
      1/2. + CSUM      SIS19680
100    CONTINUE      SIS19690
C                                                                              SIS19700
243    SUM = (CHI(1)*UTERM(N-IADJST+1) + CHI(2)*UTERM(N-IADJST))/2.      SIS19710
      1+ CSUM      SIS19720
C                                                                              SIS19730
      IF(MM.NE.1) GO TO 101      SIS19740
      YF = YFUNCT(N,HDEL,CHI,NOCHI)      SIS19750
      N2 = (N+1) - (N/NOPNTS*NOPNTS)      SIS19760
      CC = ESOUFC(N2)      SIS19770
101    CDUM = COMJG(UTERM(N-IADJST+1)) * SUM * HDEL +      SIS19780
      1CONJG(UTERM(N-IADJST+1)) * YF      SIS19790
      ZTERM(N-IADJST+1) = -CC + AIMAG(CDUM)      SIS19800

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C
C      VTST = ((-1./CAP*(ZTERM(N-IADJST+1)+ZTERM(N-IADJST)))/2.
C      1-1./2./CAP/RNN*VOLT(N-IADJST)) *
C      1HDEL + VOLT(N-IADJST))/(1.+HDEL/2./RNN/CAP)
C
C      VTST = -1.0 * RNN * ZTERM(N-IADJST+1)
C
C      ITS2 = N - IADJST + 1
C      IF(ABS(VTST-VOLT(ITS2)).LT.TOL*ABS(VOLT(ITS2)))
1GO TO 450
C      IF(MM/2*2.EQ.MM) GO TO 421
C
C      423 VOLT(N-IADJST+1) = (VTST + VOLT(N-IADJST+1))/2.
C      PHASE(N-IADJST+1) = PHASE(N-IADJST) + AIMAG(CONST) *
1(VOLT(N-IADJST+1)+VOLT(N-IADJST))/2.
C      CALL FIXPHA(PHASE(N-IADJST+1))
C      CTEMP = CMPLX(0.,PHASE(N-IADJST+1))
C      UTERM(N-IADJST+1) = CEXP(CTEMP)
C      GO TO 422
C
C      421 IF(ABS(VMID2-VPREV) .LT. TOL*ABS(VMID2)) GO TO 423
C      VG = (VTST - VMID1) / (VMID2 - VPREV)
C      IF(ABS(1.-VG) .LT. TOL) GO TO 423
C      VOLT(N-IADJST+1) = (VMID1 - VG*VPREV) / (1. - VG)
C      PHASE(N-IADJST+1) = PHASE(N-IADJST) + AIMAG(CONST) *
1(VOLT(N-IADJST+1) + VOLT(N-IADJST))/2.
C      CALL FIXPHA(PHASE(N-IADJST+1))
C      CTEMP = CMPLX(0.,PHASE(N-IADJST+1))
C      UTERM(N-IADJST+1) = CEXP(CTEMP)
C
C      422 VMID1 = VTST
C      VPREV = VMID2
C      VMID2 = VOLT(N-IADJST+1)
C
C      425 CONTINUE
C
C      WRITE(6,234)
C      234 FORMAT(1X,'*****PROBLEM: ITERATION LOOP 1 EXPIRED')
C
C      STOP
C
C      450 ITS10 = N - IADJST + 1
C      IF(VOLT(ITS10) .LT. VTHRS) VCNT = VCNT + 1
C
C      IF(RR.EQ.NOPNTS) GO TO 600
C
C      500 CONTINUE
C
C      A WATCH IS KEPT ON HOW MANY VOLTAGE POINTS IN
C      THE WAVEFORMS ARE NEGATIVE VOLTAGES
C
C      600 IF(VCNT .EQ. 0) GO TO 620
C      WRITE(6,601) VCNT, I
C      601 FORMAT(1X,'SIS:VOLTAGE THRESHOLD COUNTER = ',I5,'ITN NO = ',I5)
C
C      620 IF(I.LE.ITYPE) GO TO 1000
C      CALL COMP2(VOLT,I,NOPNTS,FLAG,ITYPE,NOCHI,IADJST)

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SIS19810
SIS19820
SIS19830
SIS19840
SIS19850
SIS19860
SIS19870
SIS19880
SIS19890
SIS19900
SIS19910
SIS19920
SIS19930
SIS19940
SIS19950
SIS19960
SIS19970
SIS19980
SIS19990
SIS20000
SIS20010
SIS20020
SIS20030
SIS20040
SIS20050
SIS20060
SIS20070
SIS20080
SIS20090
SIS20100
SIS20110
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SIS20210
SIS20220
SIS20230
SIS20240
SIS20250
SIS20260
SIS20270
SIS20280
SIS20290
SIS20300
SIS20310
SIS20320
SIS20330
SIS20340
SIS20350

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      IF(FLAG) GO TO 2000                                SIS20360
1000 CONTINUE                                          SIS20370
C                                                       SIS20380
      WRITE(6,233)                                       SIS20390
233  FORMAT(1X,'*****PROBLEM: ITERATION LOOP 2 EXPIRED') SIS20400
      NOSTOP = N + 1                                     SIS20410
      RETURN                                             SIS20420
C                                                       SIS20430
2000 WRITE(6,655) ITYPE, ISTO                          SIS20440
655  FORMAT(1X,'SIS:PERIODICITY OBTAINED WITH ITYPE = ',I5, SIS20450
      1/1X,'SIS:NO. OF ITERATIONS = ',I5)              SIS20460
      NOSTOP = N + 1                                     SIS20470
      RETURN                                             SIS20480
      END                                               SIS20490
      FUNCTION YFUNCT(N,HDEL,CHI,NOCHI)                SIS20500
C                                                       SIS20510
      REAL CHI(NOCHI)                                    SIS20520
C                                                       SIS20530
C THIS FORMS PART OF THE CALCULATION OF THE CONVOLUTION SIS20540
C FORMULA IN THE SIS EQUATIONS                       SIS20550
C                                                       SIS20560
      YFUNCT = 0.0                                       SIS20570
      IF(N.GE.NOCHI) RETURN                             SIS20580
C                                                       SIS20590
      NPLUS1 = N + 1                                     SIS20600
      NMIN1 = NOCHI - 1                                  SIS20610
      DO 20 I = NPLUS1,NMIN1                             SIS20620
      YFUNCT = YFUNCT + (CHI(I)+CHI(I+1))/2.0*HDEL     SIS20630
20  CCONTINUE                                           SIS20640
      RETURN                                             SIS20650
C                                                       SIS20660
      END                                               SIS20670
      SUBROUTINE COMP2(VOLT,I,NOPNTS,FLAG,ITYPE,NOCHI,IADJST) SIS20680
      LOGICAL FLAG                                       SIS20690
      REAL VOLT(NOCHI)                                    SIS20700
      DATA TOL, EPS/1.E-4,1.E-1/                       SIS20710
C                                                       SIS20720
C THIS SUBROUTINE COMPARES THE TWO MOST RECENT       SIS20730
C SUCCESSIVE VOLTAGE WAVEFORMS IN THE SIS WAVEFORM  SIS20740
C ITERATION PROCESS                                   SIS20750
C                                                       SIS20760
      EMAX = 0.0                                         SIS20770
      IPNT = 0                                           SIS20780
      FLAG = .TRUE.                                       SIS20790
      IF(I.LE.ITYPE) GO TO 1000                          SIS20800
C                                                       SIS20810
      CMAX = 0.                                          SIS20820
      DO 100 M = 1,NOPNTS                                SIS20830
      MI = (I - 1) * NOPNTS + M - IADJST                SIS20840
      IF(ABS(VOLT(MI)) .GT. CMAX) CMAX = ABS(VOLT(MI))  SIS20850
100  CONTINUE                                           SIS20860
C                                                       SIS20870
      IF(CMAX .LT. 1.E-12) RETURN                       SIS20880
C                                                       SIS20890
      DO 500 J = 1,NOPNTS                               SIS20900

```

FILE: SISCAP FORTRAN A NASA/GISS CONVERSATIONAL MONITOR SYSTEM SP302

```

IPOINT = (I-1) * NOPNTS + J - IADJST
ISEEK = IPOINT - NOPNTS * ITYPE
IF(ISEEK.LE.0) GO TO 500
IF(ABS(VOLT(IPOINT)).LT.EPS*CMAX) GO TO 500
ERROR = (VOLT(IPOINT)-VOLT(ISEEK))/VOLT(IPOINT)
ERROR = ABS(ERROR)
IF(ERROR .LT. EMAX) GO TO 400
EMAX = ERROR
IPNT = J
400 IF(ERROR .LT. TOL) GO TO 500
FLAG = .FALSE.
500 CONTINUE
RETURN
C
1000 FLAG = .FALSE.
RETURN
END
SUBROUTINE FIXPHA(X)
DATA PI/3.1415926/
C
C THIS PERFORMS A MODULO FUNCTION ON THE PHASE
C CALCULATIONS IN THE SIS EQUATIONS
C
IF(ABS(X).LT.2.0*PI) RETURN
NOREV = X / 2.0 / PI
X = X - 2.0 * PI * FLOAT(NOREV)
RETURN
END

```

SIS20910
SIS20920
SIS20930
SIS20940
SIS20950
SIS20960
SIS20970
SIS20980
SIS20990
SIS21000
SIS21010
SIS21020
SIS21030
SIS21040
SIS21050
SIS21060
SIS21070
SIS21080
SIS21090
SIS21100
SIS21110
SIS21120
SIS21130
SIS21140
SIS21150
SIS21160
SIS21170
SIS21180

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16 Abstract <p>This report describes user oriented computer program SISCAP (SIS Computer Analysis Program) for analysing SIS mixers. The program allows arbitrary impedance terminations to be specified at all LO harmonics and sideband frequencies. It is therefore able to treat a much more general class of SIS mixers than the widely used three-frequency analysis, for which the harmonics are assumed to be short-circuited. An additional program, GETCHI, provides the necessary input data to program SISCAP.</p> <p>The program SISCAP performs a nonlinear analysis to determine the SIS junction voltage waveform produced by the local oscillator. The quantum theory of mixing is used in its most general form, treating the large signal properties of the mixer in the time domain. A small signal linear analysis is then used to find the conversion loss and port impedances. The noise analysis, includes thermal noise from the termination resistances and shot noise from the periodic LO current. Quantum noise is not considered.</p> <p>Many aspects of the program have been adequately verified and found accurate. However, this project was terminated before the program was extensively employed, and it is possible that errors may occur in various untested parameter ranges.</p> <p>An example is given, which forms part of some initial investigations into the effect of decreasing the SIS junction capacitance on the performance of a simple SIS mixer circuit. Early indications are that, for this circuit, a high $\omega_p R_N C_J$ product is desirable.</p>			
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