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THE SOFTWARE SYSTEM DEVELOPMENT FOR THE TAMU REAL-TIME FAN BEAM SCATTEROMETER DATA PROCESSORS

By

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TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

THE SOFTWARE SYSTEM DEVELOPMENT FOR THE TAMU REAL-TIME FAN BEAM SCATTEROMETER DATA PROCESSORS

1.0 SUMMARY

The Remote Sensing Center at Texas A&M University (TAMU) has developed a real-time radar signal processor for the NASA fan beam scatterometer system. The development of the system and hardware design of the real-time processor is documented in Final Report RSC-3556, "The System and Hardware Design of Real-Time Fan Beam Scatterometer Data Processors," March 1979 [1]. This current report presents the details of the development of the software system for the signal processors.

The software package has been designed and written to process in real-time any one quadrature channel pair of radar scatterometer signals from the NASA L- or C-Band radar scatterometer systems. The software has been successfully tested in the C-Band processor breadboard hardware using recorded radar and NERDAS (NASA Earth Resources Data Annotation System) signals as the input data sources.

Contained in this report are a brief review of the processor development program, a concise yet complete description of the overall processor theory of operation and design, a detailed description and documentation of the real-time processor software system, the results of the laboratory software tests, and recommendations for the efficient application of the data processing capabilities provided by the TAMU Real-Time Scatterometer Processing System.

In the interest of efficiency and economy, some of the material presented in this report has been extracted from Final Report RSC-3556 [1] with only minor or no modification. Such material has been included to provide as nearly complete documentation in this volume of the overall processor system as is necessary to fully understand its operation, capabilities and limitations. For the detailed documentation of the breadboard hardware and the engineering model design it is still necessary to refer to the earlier report.

2.0 INTRODUCTION

2.1 Historical Background

The NASA Johnson Space Center operates a set of airborne fan beam scatterometers for support of various earth and space related programs. Data from an early system proved helpful in identifying an ocean wind measurement technique. This work eventually led to the scatterometer system aboard SEASAT A. Raw scatterometer signals from these early experiments were post processed into quantitative engineering unit data using a general purpose computer. The time and expense required to process data caused the delay between data acquisition and data product delivery to be excessive. As a result, utilization of the scatterometers was limited and they were eventually removed from service.

More recently, radar data requests by the NASA soil moisture program provided enough justification to warrant reinstating the 0.4 GHz, 1.6 GHz and 13.3 GHz scatterometers into service, and constructing a new 4.75 GHz scatterometer. The earlier experiences with scatterometer data processing led to a program to develop faster, cheaper methods of data handling and processing. The initial thrust of the program produced a demonstration processor for use with the 13.3 GHz scatterometer. The philosophy behind this processor was to provide a real-time quick capability for verifying data characteristics (i.e., system operation) and 2) provide a method of identifying those data to be post processed on a large computer to the accuracies needed for analysis. This processor was developed and constructed at TAMU under NASA contract [2] to process polarization channel over a limited set of viewing angles. In addition to this hardware processor, TAMU developed software routines for general purpose computers to reduce raw data to calibrated engineering units.

Recent advances in signal processing technology have suggested that by combining analog and digital processing methods into a single processor, real-time on board processing and real-time rate post time processing of scatterometer data to calibrated engineering units could be accomplished. Such a system could provide all of the capability in terms of viewing angles, resolution and adaptability that the post time software systems previously developed could provide, with a potential for more accurate results as a result of eliminating the analog recorder when operating in a real-time mode. Such a system would provide experimenters with calibrated data on a timely basis with fewer manhours from data flight to delivery. This realization provided the basis for the current efforts reported in this document.

2.2 Design Objective and Overview

Designs for two airborne radar scatterometer processors for use with the NASA 1.6 GHz and 4.75 GHz scatterometers were identified and anlayzed. A portion of the processor was implemented to evaluate a "state-of-the-art" component proposed for use in the processor. This component permitted a standarized design approach which is extendable to other NASA fan beam scatterometers. The current effort exploited design experiences from previous hardware and software processors to minimize significant error contributions and to assure repeatability in performance. However, innovations were also introduced as a result of the hybrid sampled analog and digital approach to provide a flexible operator/experimenter oriented system. As a result of these new insights, major improvements were also identified for use in the purely software approaches to processing scatterometer data. This benefitted another NASA sponsored program to develop a more efficient software routine to process scatterometer data on an interim basis while the hardware processors undergo development. This latter effort ran concurrently with the processor development program and afforded an opportunity to also test, anticipate and prove the characteristics of the hardware design.

The hardware design features a chirp Z-transform (CZT) approach to filtering the Doppler spread radar return. The CZT is implemented with multiplying digital to analog converters and a charge coupled transversal filter. The filtering operation reduces to that of performing a discrete Fourier transform (DFT) of the radar return when represented in complex valued form. As a consequence, no Hilbert transform operation (sign sensing) is required to separate fore and aft returns. Both are provided simultaneously with considerable reduction in circuit complexity. The subsequent processing, is actually limited to the aft data; however, the fore data is available within the processor should future efforts require it.

There are many advantages in the CZT approach. It permits high frequency resolution of Doppler return. As a consequence, the return may be measured with good angular resolution. This also permits the processor to adapt with changes in aircraft velocity to track the desired viewing angles by simply using a different set of spectral outputs. It will also permit arbitrary choices in viewing angles desired. The CZT approach can be readily applied to scatterometers operating at other wavelengths by altering the sampling frequency.

The power spectral density (PSD) of the total return is formed from the chirp Z-transformed data. The formation of the PSD requires that the spectral data be detected (squared) and accumulated (averaged) over a period of time. To achieve the accuracy and the dynamic range required in scatterometry, the detection and accumulation are accomplished digitally.

The detected and averaged data are converted to estimates of the scattering coefficients σ° at eight viewing angles over the aft sector. The conversion is implemented in software and requires the application of radar range, pattern data, viewing angle, and transmitted power to yield a calibrated result. In addition, the software permits interactive control of the processor. Since the computations and control are provided by software, any portion of the operating system can be altered should the need arise.

The design approach was partially evaluated by actually implementing a subsystem of the scatterometer processor. An evaluation to this detail was required to validate the performance and dynamic range of the charge coupled devices and associated circuitry since this is a "state-of-the-art" item.

An earlier report [1] described the system design theory, the system operating rationale and architecture, the harware and software designs and an evaluation of the CZT approach for the scatterometer processors profiled above. This report reviews the relevant system and hardware design considerations and provides detailed documentation of the newly developed processor software. In particular, Section 3.0 reviews the system design theory background. The characteristitcs of CW fan beam scatterometers are related to the scatterometer equation to identify the measurement theory. It is shown that the angular scattering characteristic can be resolved by estimating the PSD of the radar return. The precision by which the PSD estimated is related to the time bandwidth product by analogy with classical fading theory. The technique by which the fore and aft spectra are separated using a DFT method is then identified. The DFT is related to the CZT and the means by which the CZT may be implemented is then established.

Section 4.0 is dedicated to establishing a suitable operating rationale for the processor. Trade-offs between angular resolution, ground resolution, precision and beam resolution are established and evaluated to identify a suitable operating mode to satisfy user requirements and system constraints.

Section 5.0 describes in detail the system architecture and carefully distinguishes between the target system and the engineering development model. An overview of the internal operation of the system is also presented.

Section 6.0 provides a complete description of the software system that has been developed for the real-time data processors. The software system provides fully calibrated normalized radar cross-section data for eight angles of incidence. The output data are fully annotated with all relevant aircraft, sensor, and processor ancillary data in a single serial bi-ϕ L channel.

3.0 DESIGN THEORY

3.1 Introduction

Airborne fan beam scatterometers permit simultaneous backscatter observations over a range of incident angles. By confining the antenna beam width in the crosstrack dimension and spreading the beam in the along track dimension, Doppler filtering may be employed in a CW system to resolve the average return power at various incident angles, each of which is spanned by a small angular window as illustrated by Figure 3.1. Combinations of transmit and receive polarizations permit like and cross polarized scattering properties of distributed targets to be measured. When the aircraft is flown over the same distributed target at different headings about the compass, the azimuthal as well as the incident angular behaviors may be documented.

3.2 The Scatterometer Equation and Fan Beam Systems

For a large class of distributed targets the returns from slightly different angular directions are essentially uncorrelated. Where a particular direction is denoted by (θ,ϕ) within the coordinte system of Figure 3.2, the total return power may be described by summing returns from patches of the target located in various angular directions (θ_i, ϕ_j). If the radar cross section in direction (θ_i,ϕ_j) is denoted by $\sigma_{pq}(\theta_i,\phi_j)$, the total return power may be expressed as

$$W_r' = \frac{\lambda^2}{(4\pi)^3} W_t \sum_{i=1}^{N} \sum_{j=1}^{M} G_{tp}(\theta_i, \phi_j) G_{rq}(\theta_i, \phi_j) \sigma_{pq}(\theta_i, \phi_j)/R^4{}_i \qquad (3.1)$$

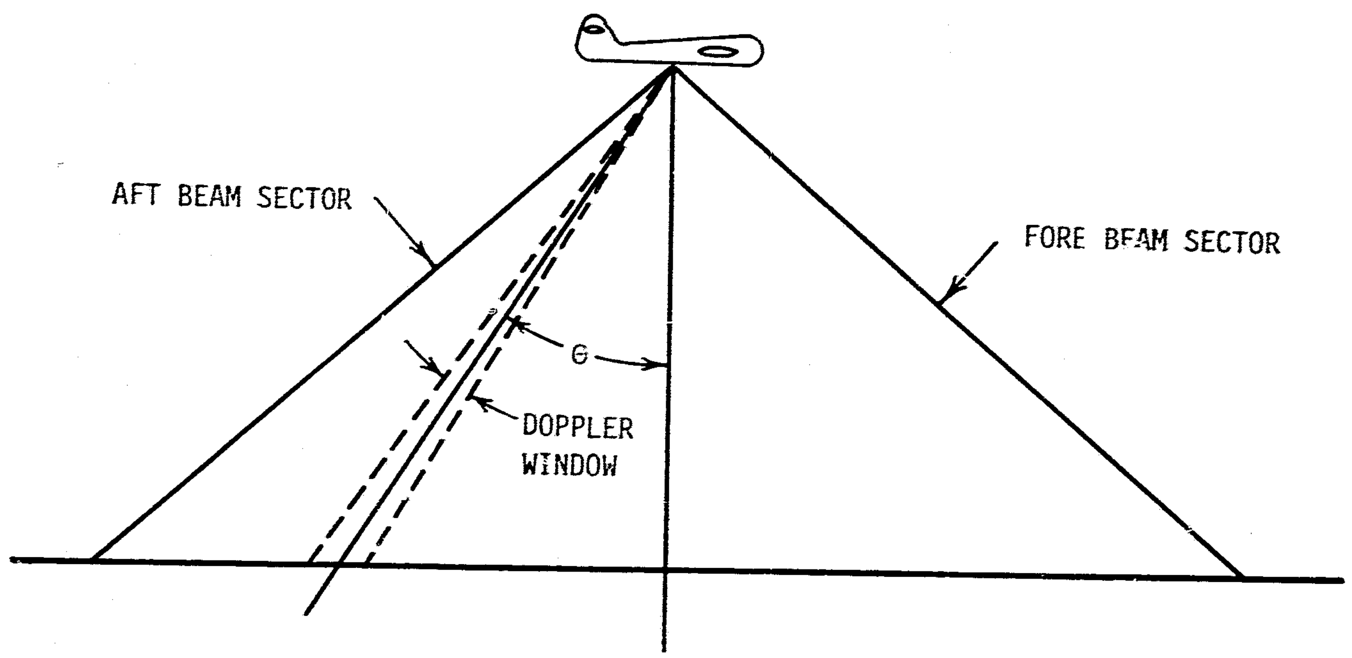


FIGURE 3.1 DOPPLER PROCESSING AND THE FAN BEAM SCATTEROMETER

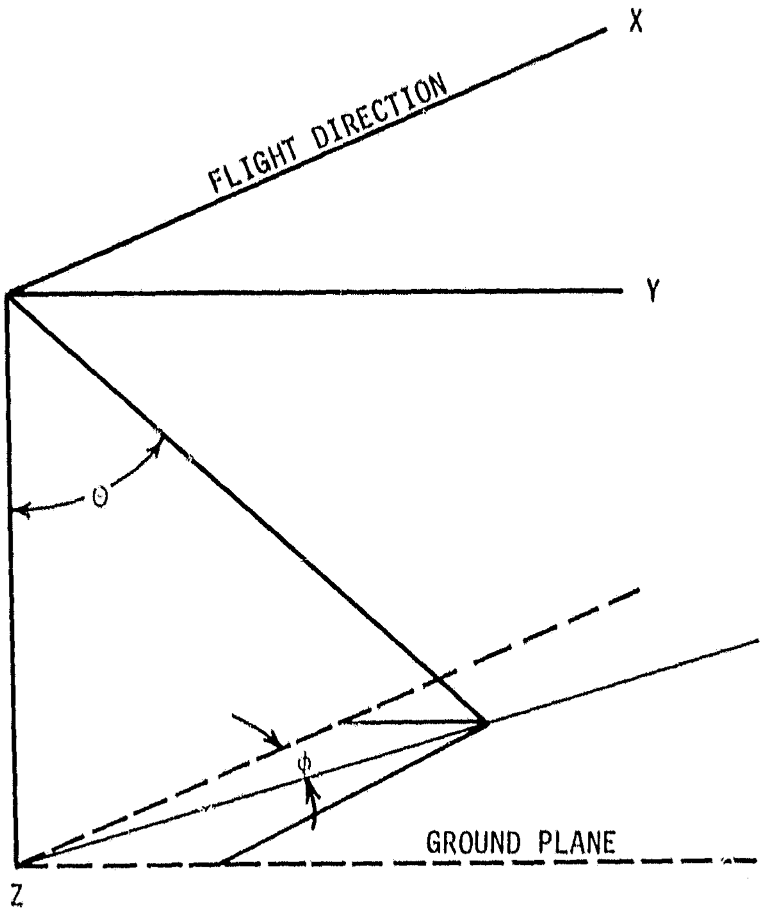


FIGURE 3.2 SCATTEROMETER GEOMETRY

where λ = radar wavelength

G_{tp} = transmit pattern directivity for polarization state p

G_{rq} = receive pattern directivity for polarization state q

W_t = total transmitted power

$R_i = h/\cos\theta_i$

h = aircraft altitude

p,q = indices denoting the transmit and receive polarization states, respectively

In order to primarily discriminate the backscatter within an angular sector of the incident angle θ, a Doppler filter, whose normalized transfer function is given by $H(\omega)$, is employed (see Figure 3.1). The portion of the return power appearing at the output of the filter is therefore given by

$$W_r = \frac{\lambda^2 W_t}{(4\pi)^3} \sum_{i=1}^{N} \sum_{j=1}^{M} G_{tp}(\theta_i,\phi_j)\, G_{rq}(\theta_i,\phi_j)\, \sigma_{pq}(\theta_i,\phi_j) \left|H(\omega_{ij})\right|^2 / R_i^4 \tag{3.2}$$

where

$$\omega_{ij} = 4\pi\, v \sin\theta_i \cos\theta_j/\lambda \tag{3.3}$$

is the radian frequency associated with the patch in direction (θ_i,ϕ_j). When the normalized scattering coefficient $\sigma^o_{pq}(\theta,\phi)$ is introduced, the double summation may be replace with a double integral given by

$$W_r = \frac{\lambda^2 W_t}{(4\pi)^3} \iint \frac{G_{tp} G_{rq}\, \sigma^o_{pq} \left|H(\omega)\right|^2 \, dA}{R^4} \tag{3.4}$$

In the interpretation of W_r it is important to realize that $\left|H(\omega)\right|^2$

participates within the integration since ω is dependent on (θ,ϕ). In an ideal fan beam scatterometer, ϕ ranges over a small interval about zero since the crosstrack antenna beam width is small. As a consequence

$$\omega \approx 4\pi\, v \sin\theta/\lambda \tag{3.5}$$

It is then observed that $|H(\omega)|^2$ plays the role of a normalized antenna pattern having discriminatory power in the θ dimension.

When the bandwidth of the Doppler filter is sufficiently narrow, σ^0_{pq} may be regarded as constant over the area A spanned by the Doppler bandwidth and the crosstrack beamwidth. The scatterometer equation (3.4) then reduces to the form

$$W_r(\theta_o) \cong \frac{\lambda^2 W_t}{(4\pi)^3}\ \frac{\sigma^0{}_{pq}(\theta_o)}{h^4} \iint G_{tp}G_{rq}\,|H|^2\cos^4\theta\, dA \tag{3.6}$$

where θ_o is the incident angle corresponding to the center frequency ω_o of the Doppler filter, i.e.,

$$\omega_o = 4\pi\, v \sin\theta_o/\lambda \tag{3.7}$$

The recovery of $\sigma(\theta_o)$ is, therefore, dependent on measurement of W_r, W_t and h and on an estimate of the double integral. In this regard the integral is often approximated by introducing an effective area A_{eff} so that

$$\iint G_tG_r|H|^2\cos^4\theta\, dA = G_t(\theta_o,0)G_r(\theta_o,0)\ \cos^4\theta_o\, A_{eff} \tag{3.8}$$

3.3 Precision in Estimating σ^o_{pq}

In order to estimate σ^o_{pq} at a set of incident angles θ_{oi}, $i=1,2,\ldots,n$, a bank of filters is required. The center frequency of each filter is chosen in accord with equation (3.7). If $S(\omega)$ is the spectral density of the return signal, then the output of the ith filter H_i is given by

$$W_r(\theta_{oi}) = 2 \int_o^\infty |H_i(\omega)|^2 \; S(\omega)df \qquad (3.9)$$

An alternative method could, instead, measure (estimate) the power spectral density (PSD) of the return signal and then form the return power through an integration, viz.,

$$W_r = 2 \int_{f_{li}}^{f_{ui}} S(\omega)df \qquad (3.10)$$

where f_{ui} and f_{li} are the upper and lower corner frequencies associated with the ith angle. In the latter case the measurement of σ^o_{pq} has been reduced to a problem in estimating the power spectral density.

Regardless of the approach, it is necessary to reduce the variance in the estimate of the mean power return W_r to assure a good estimate of the average scattering coefficient σ^o_{pq}. As is well known, the radar return is characterized by heavy fading since the signal has a Rayleigh-like amplitude distribution [3]. As a consequence, it is difficult to estimate the mean squared statistic of such a signal. The theory for the precision in the estimating the mean squared statistic appears in references [3], [4] and others. The extrapolation of this theory to the case where the PSD is to be estimated can be established on an intutive basis and is made precise in reference [5]. The PSD is estimated from the periodogram and is defined by

$$S_N(k) = \frac{1}{N} \left| \sum_{n=0}^{N-1} s(n)\, e^{-j\, 2\pi\, kn/N} \right|^2 \tag{3.11}$$

for the kth spectral line for a signal represented in sampled form $\{s(o), s(1), \ldots, s(N-1)\}$.

In the case where analog filtering, detection and integration is performed, it is well known that the standard deviation σ in the estimate of W_r is given by [4]

$$\sigma = W_r/\sqrt{BT} \tag{3.12}$$

where B is the pre-detection (effective) bandwidth and T is the integration period. The dependence of the variance ratio $\sigma^2/W_r{}^2$ on the BT product is illustrated in Figure 3.3.

Although the variance reduction is a good indication of the improvement in the estimate of W_r, the precision of a system is better conveyed by a statistical 90% confidence interval. The 90% confidence interval for a BT product of 10 or better can be approximated by [6]

$$\overline{W}_r - 1.645\sigma \le \overline{W}_r \le \overline{W}_r + 1.645\sigma \tag{3.13}$$

where $\overline{W}_r$ is the estimate of W_r. When the span of this confidence interval is expressed in dB, it can be written as

$$R = 10 \text{ Log } \frac{1 + 1.645/\sqrt{BT}}{1 - 1.645/\sqrt{BT}} \tag{3.14}$$

The dependence of this precision factor on the time bandwidth product is illustrated in Figure 3.4. It is observed that a $\pm$ 1 dB confidence interval

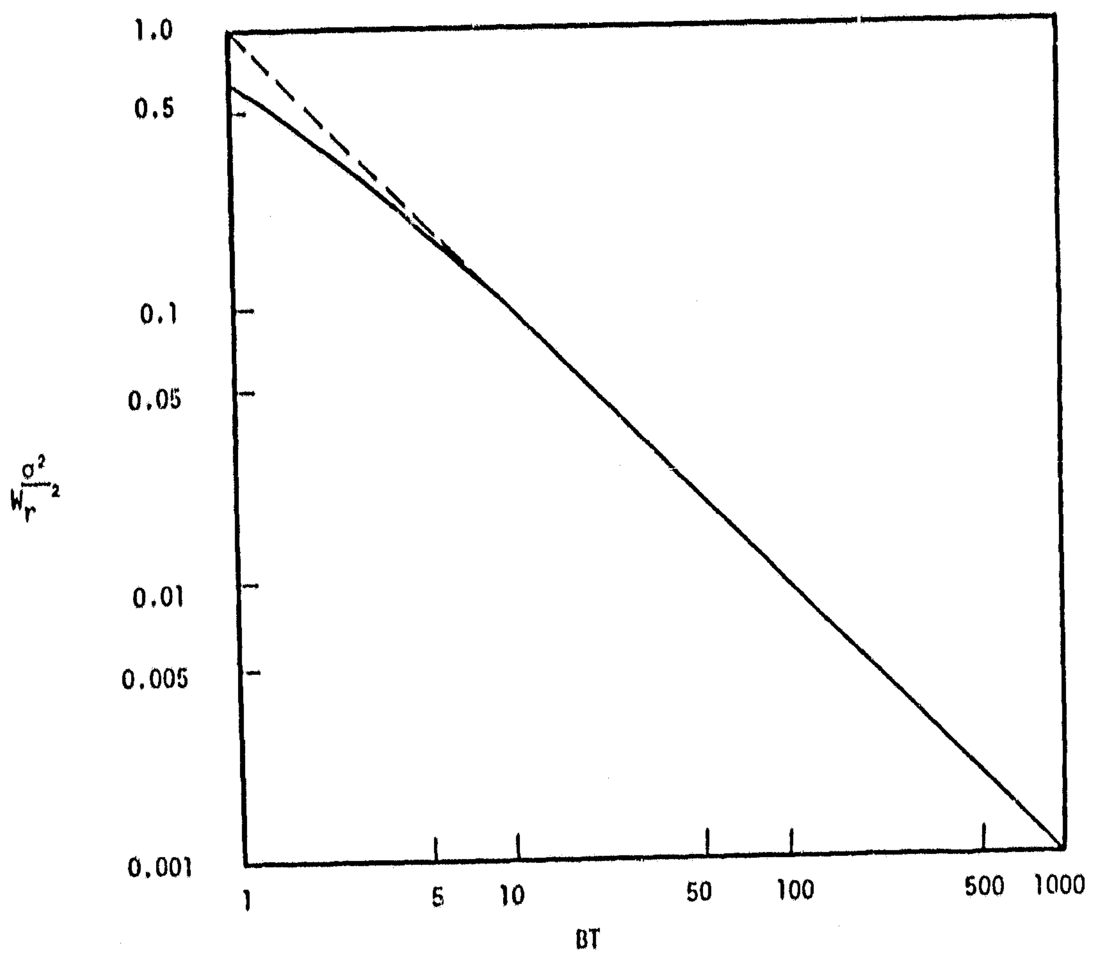


FIGURE 3.3 THE VARIANCE RATIO AS A FUNCTION OF INTEGRATION TIME-BANDWIDTH PRODUCT (FROM REFERENCE [2])

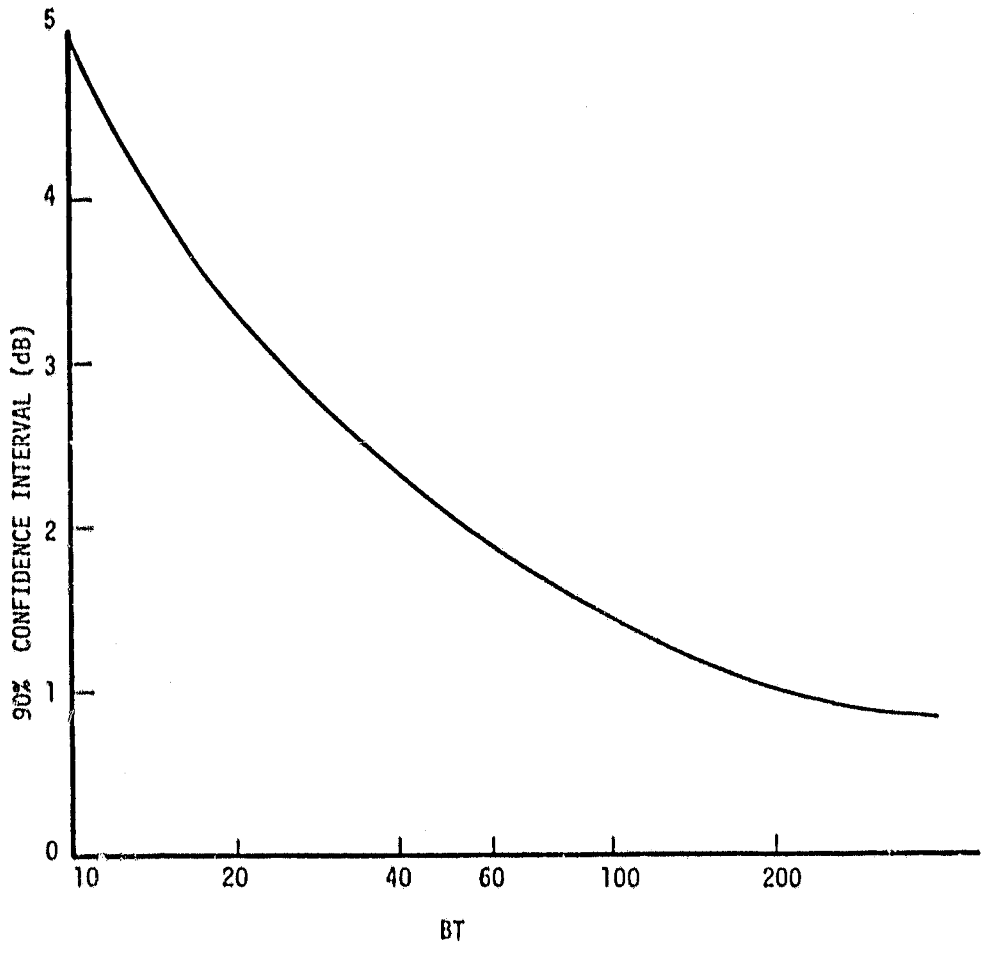


FIGURE 3.4 THE IMPROVEMENT IN PRECISION WITH THE TIME BANDWIDTH PRODUCT

requires a BT product of 50. Furthermore, it is noted that the improvement in precision becomes less rapid when BT > 100.

The above theory can also be applied to the case where the PSD is determined from the periodogram. To obtain precision in the estimate of the PSD, the periodogram must be averaged. This can be accomplished by averaging spectral estimates from a sequence of records and by smoothing adjacent spectral lines from a single record. To make the association between the precision for an analog processor with that for a PSD processor, it should be noted that the PSD estimates are based on the discrete Fourier transform (DFT) of the return signal s(t) (see equation (3.18)). The effective bandwidth associated with DFT processing (filtering) is given by

$$\Delta f = \frac{1}{T} \qquad (3.15)$$

where T is the duration of the signal record. It has been assumed that the record is unweighted. Therefore, the time bandwidth product associated with a single line from a single record is simply

$$BT = \Delta f T \qquad (3.16)$$

or 1. Since the spectral estimates from a single record are poorly correlated, the BT product can be enhanced by averaging over a window of adjacent spectral lines. The BT product can be further enhanced by averaging line estimates from a sequence of non-overlapping records. So, if N_f adjacent lines from each record are smoothed and N_R non-overlapping records are processed, the resulting BT product for a filter of width $N_F \Delta f$ is given by

$$BT = (N_F \Delta f)(N_R T) \tag{3.17}$$

or simply $N_F N_R$. This result indicates that the precision improvement is identical for analog and PSD processing.

3.4 Power Spectral Estimation Using the Chirp Z-Transform

As indicated above, the estimate of the PSD can be based on the DFT of a radar return record. If $s(n)$, $n = 0,1,2,\ldots,N-1$ is an N point sequence representing the return signal $s(t)$ over a time interval T, then the DFT of $s(t)$ is defined as

$$F(k) = \sum_{n=0}^{N-1} s(n)\, e^{-j2\pi kn/N} \tag{3.18}$$

where $k \in \{0,1,2,\ldots,N-1\}$. $F(k)$ is interpreted as the spectral amplitude of $s(t)$ at a frequency of k/T when $0 \le k \le \frac{N}{2}$ and at a frequency of $-(N-k)/T$ for $\frac{N}{2} < k < N - 1$. It has been assumed that N is even. The DFT formulation may be modified through the use of the identity

$$2nk = n^2 + k^2 - (k - n)^2 \tag{3.19}$$

to permit an implementation of the DFT by hardware. The identity results in a DFT given by

$$F(k) = e^{-j\pi k^2/N} \sum_{n=0}^{N-1} s(n) e^{-j\pi n^2/N}\, e^{\,j\pi(k-n)^2/N} \tag{3.20}$$

The implication of the above result is that $s(n)$ must be first down-chirped with $e^{-j\pi n^2/N}$, convolved with an up-chirp $e^{j\pi n^2/N}$ and then post multiplied by a down-chirp $e^{-j\pi k^2/N}$. The pre and post multiplications may be performed by analog methods and the convolution may be formed with transversal filters using charge coupled devices. The transversal filter requires 2N-1 stages to implement the DFT. When forming the PSD, the post chirp may be discarded since it does not affect the amplitude.

A more efficient means for implementing the transversal filter, requiring only N stages in the transversal filter, is based on the sliding DFT. The sliding transform is defined as

$$F_s(k) = \sum_{n=k}^{k+N-1} s(n)e^{-j2\pi nk/N} \tag{3.21}$$

and differs from the non-sliding version in that the input sequence is shifted forward one sample for each new spectral estimate. The transform consequently operates continuously. Spectral estimates on the same line are updated every N samples since $e^{-j\pi nk/N}$ is modulo N in the parameter k. As a result of the sliding action, phase information is destroyed; nevertheless, the magnitude information important to the PSD estimation is preserved.

It can be shown that through the use of the identity of equation (3.19), the sliding transform can be rewritten as

$$F_s(k) = e^{-j\pi k^2/N} \sum_{m=1}^{N} e^{j\pi(m-N)^2} s(k - m + N)e^{-j\pi(k - m + N)^2/N} \tag{3.22}$$

This result implies that the input must be pre-chirped by a factor $e^{-j\pi(m-N)^2/N}$, convolved with $e^{j\pi(m-N)^2/N}$ and then post multiplied with $e^{-j\pi k^2/N}$ to form the sliding DFT. When the PSD is required, the post multiplication may be replaced with a squaring operation to yield $|F_s(k)|^2$. Since the pre-multiplication is periodic in m, the CZT filter can operate on the input signal continuously with the transversal filter only requiring N stages.

3.5 The Application of the CZT to Doppler Filtering

3.5.1 Signal Processing Theory

A simplified block diagram of the CW fan beam scatterometer is illustrated in Figure 3.5. The transmitter illuminates the terrain at a radian frequency of ω_o. The backscattered signal arriving at the receiver may be denoted as

$$s(t) = a(t) \cos [\omega_o t + \phi(t)] \tag{3.23}$$

where a(t) and $\phi(t)$ may be regarded as random variables. The spectrum of s(t) is depicted symbolically in Figure 3.6a. The fore and aft spectra are distinguished from one another by "coloring" the fore spectrum as a rectangle and the aft spectrum as a triangle. As indicated in the receiver chain, the return signal is split equally into two channels. This signal in the upper channel is coherently demodulated with cos $\omega_o t$ and low pass filtered to yield

$$x(t) = \tfrac{1}{2} a(t) \cos\phi(t) \tag{3.24}$$

The upper channel is commonly called the cosine channel or the in-phase (I) channel. Demodulation and low pass filtering in the lower channel yields

$$y(t) = \tfrac{1}{2} a(t) \sin\phi(t) \tag{3.25}$$

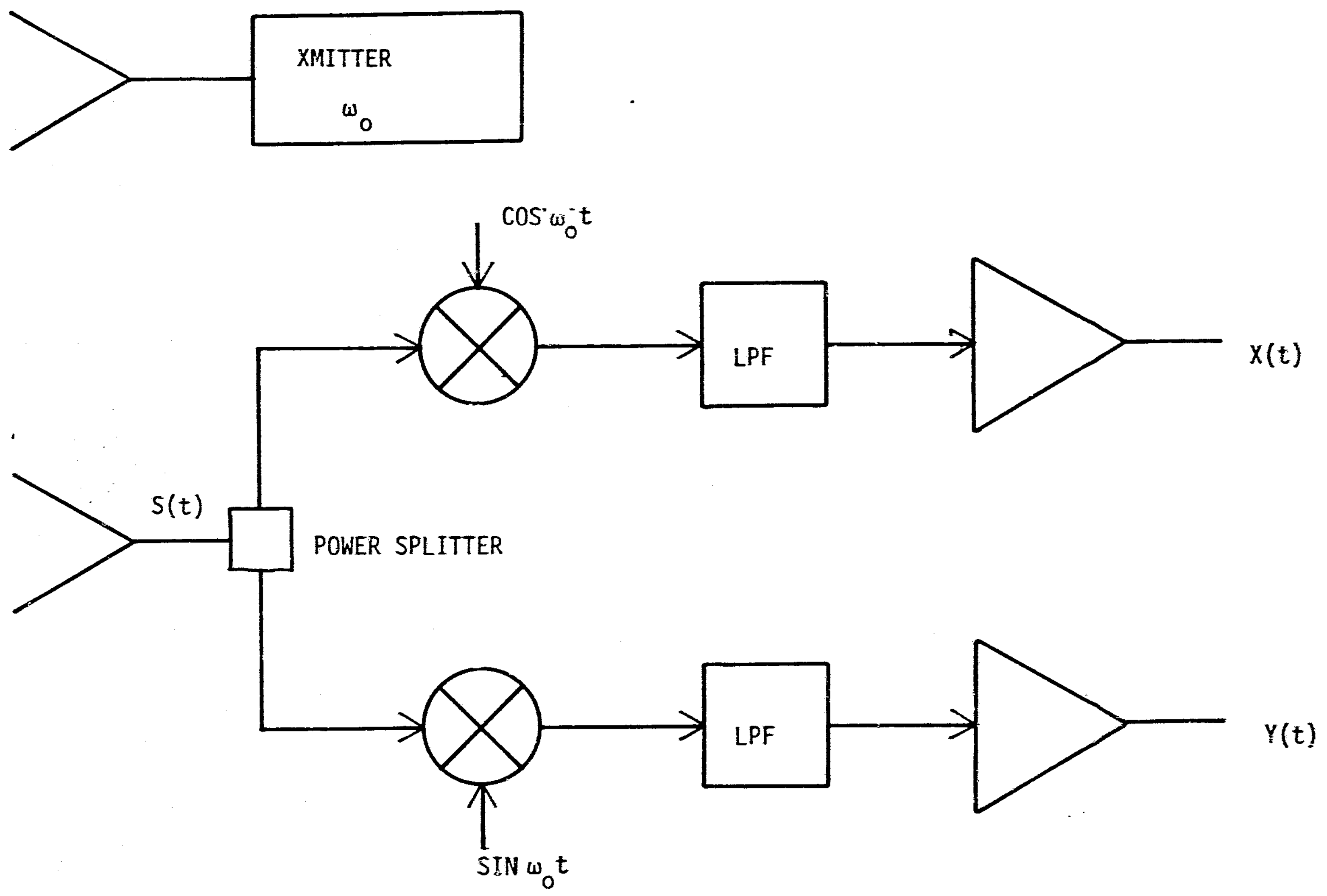


FIGURE 3.5 A SIMPLIFIED BLOCK DIAGRAM OF THE CW FAN BEAM SCATTEROMETER

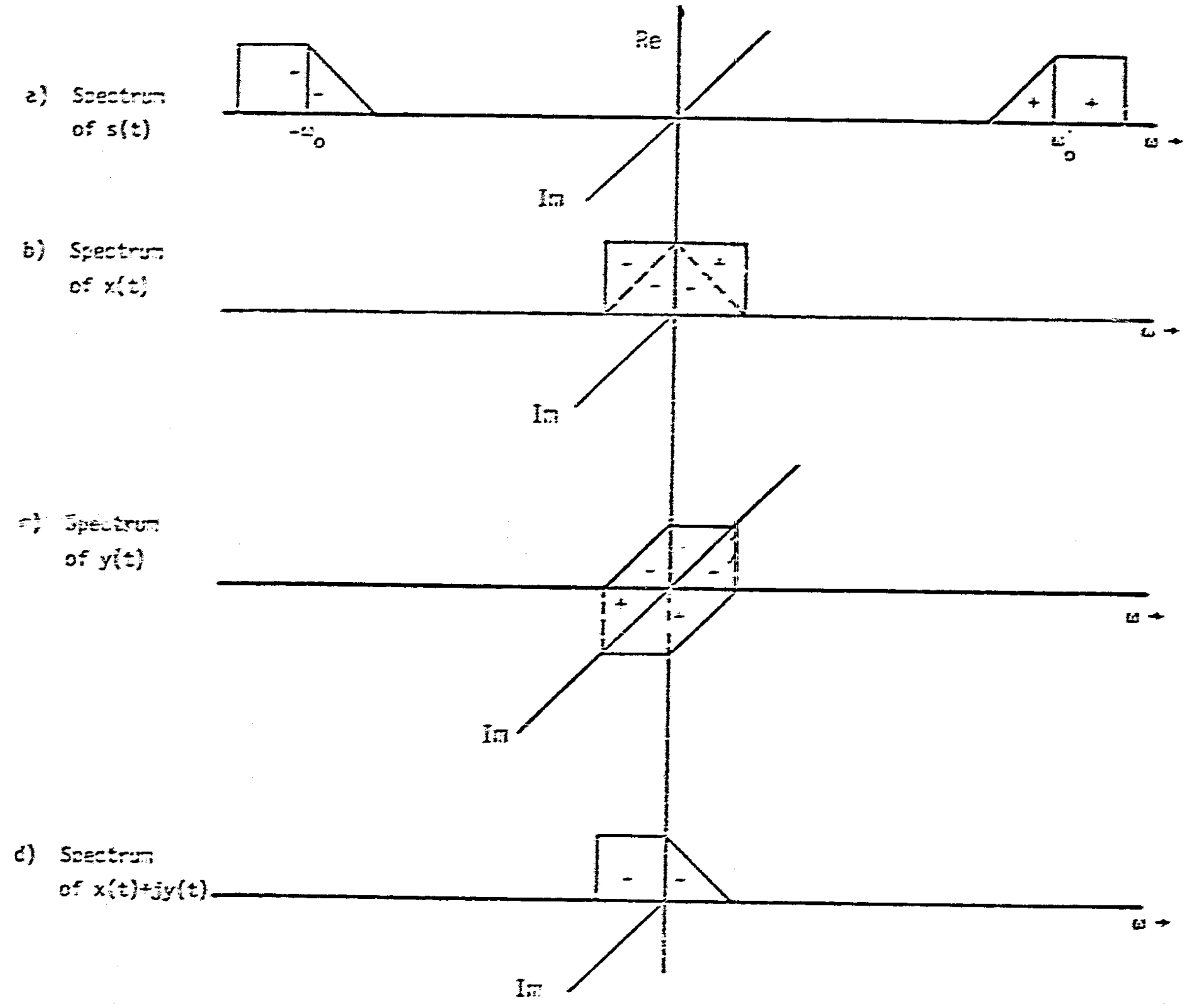


FIGURE 3.6 SPECTRA OF INTEREST

where product modulation with the quadrature reference sin $\omega_0 t$ has occurred. The lower channel is commonly called the sine channel or the quadrature (Q) channel. The spectra of x(t) and y(t) are illustrated in Figures 3.6b and 3.6c, respectively.

A comparison of Figures 3.6b and 3.6c shows that the aft and fore spectra can be retrieved simultaneously if a complex signal

$$z(t) = x(t) + j\, y(t) \tag{3.26}$$

is formed. An examination of the spectrum of z(t) indicates that the aft spectrum occurs for $\omega > 0$ and the fore spectrum for $\omega < 0$.

Since the DFT can also be applied to complex signals as well as real signals, the above result shows that the fore and aft spectra can be simultaneously filtered using CZT techniques to implement the DFT. The configuration for implementing the CZT using charge coupled devices and analog multipliers is described below.

3.5.2 The Implementation Technique

It is advantageous to use the sliding version of the CZT, since many sequential measurements are required to estimate the PSD. The actual implementation method is best understood by separating the real and imaginary parts of the sliding CZT. When the sliding CZT of z(t) is taken, $Z_s(k)$ can be rewritten in the form

$$\begin{aligned} |Z_s(k)| = \sum_{m=1}^{N} & [\cos\pi(m-N)^2/N + j \sin\pi\,(m-N)^2/N] \\ & [x(k-m+N) + jy(k-m+N)]. \qquad (3.27) \\ & [\cos\pi(k-m+N)^2/N - j \sin\pi(k-m+N)^2/N] \end{aligned}$$

A careful interpretation of the arguments within the above magnitude suggests the implementation technique shown in Figure 3.7. Both x(t) and y(t) are pre-chirped and appropriately summed to form the real and imaginary valued entries into the transversal filter bank. Four transversal filters are required to form the cross multiplication products of the complex valued signal entering the filters. The real and imaginary parts of the CZT without the post-multiplication are formed by differencing the outputs of the transversal filters as illustrated in Figure 3.7.

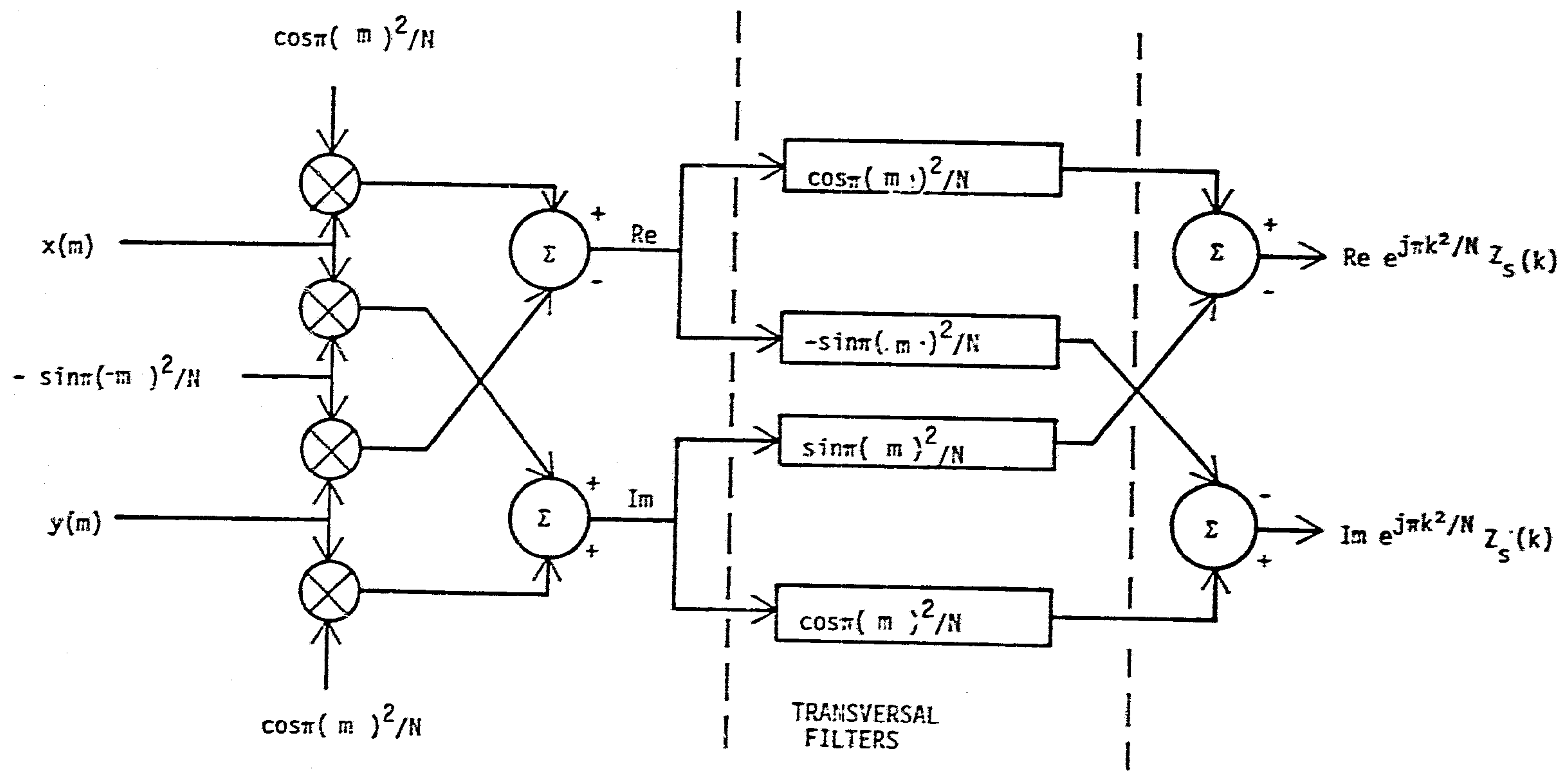


FIGURE 3.7 A TECHNIQUE FOR IMPLEMENTING THE CZT WITHOUT POST MULTIPLICATION

4.0 SYSTEM DESIGN RATIONALE

4.1 Introduction

As is the case with any system, the actual design is a compromise between user requirements and system constraints. The design of real time processors for the NASA scatterometers is no exception. Ideally the scatterometer should provide high precision estimates of $\sigma°$ with infinitesimal angular and ground resolutions. However, as will be shown below, the precision, angular resolution and ground resolution interact in such a way to prevent maximizing all three parameters simultaneously. In addition to maximizing the precision and resolution parameters, the user is also interested in achieving a reasonable accuracy to permit comparative analysis of the processed data at different view angles and polarizations and with scatterometer data from other sources (also presumably calibrated).

A list of the factors which can potentially influence the performance of the scatterometer/processor system is shown in Table 1. The source of error is described in the left-hand column. The system performance factors most influenced by the error source is reflected in the middle column. The origin of the error within the system is identified in the right-hand columns. Most of the performance parameters are manageable by the processor provided that the scatterometer has been appropriately designed. Those that are manageable are treated below as well as in subsequent chapters to develop the processor design rationale.

TABLE 4.1 FACTORS INFLUENCING SYSTEM PERFORMANCE

	Error Source	Affected Performance Factor	Origin in System			
			Scatterometer	Processor	Aircraft	Target
1.	Fading Signal	Precision				X
2.	Finite Doppler Bandwidth	Precision & Angular Resolution		X		
3.	Finite Record Length	Ground Resoltuion & Precision		X		
4.	Filter Sidelobe Level	Accuracy		X		
5.	Bit Truncation	Precision		X		
6.	Inversion Approximation	Accuracy		X		
7.	Uncertainty in Altitude	Accuracy			X	
8.	Aircraft Attitude a) Illuminated area b) Polarization decomposition	Accuracy			 X X	
9.	Transmitted Power	Accuracy	X			
10.	Polarization	Accuracy	X			
11.	Non-Stationary Return	Accuracy				X
12.	Beamwidth	Accuracy & Angular Resolution	X			
13.	Pattern Sidelobes	Accuracy	X			
14.	Pattern Gain	Accuracy	X			

4.2 Definition of System Design Parameters

To identify the processor's mode of operation it is important to define various parameters associated with fan beam systems. In this regard such terms as angular resolution, ground resolution, scan length, beam resolution, ground track coverage, etc. must be clarified to arrive at the impact of these parameters on the system design.

Angular Resolution

As indicated in Section 3.2 the angular resolution of a fan beam scatterometer is dictated by the physical beamwidth in the crosstrack dimension and by the bandwidth of the Doppler filter in the intrack dimension. If $H(\omega)$ denotes the normalized voltage transfer function of the Doppler filter, then an affective bandwidth may be defined as

$$B = \frac{1}{2\pi} \int_{-\infty}^{\infty} |H(\omega)|^2 d\omega \tag{4.1}$$

where the normalization has been applied so that $\max_{\omega} \{| H(\omega) |\} = 1$ when $H(\omega)$ represented in low pass form. An effective intrack beamwidth may be related to the effective bandwidth through the Doppler relationship

$$\Delta\theta = \frac{\lambda B}{2v\cos\theta} \tag{4.2}$$

when $\phi \simeq 0$. $\Delta\theta$ is defined to be the angular resolution.

Beam Resolution

The beam resolution in the cross track dimension is given by

$$\rho_c = (h \tan\theta)\, \Delta\phi \tag{4.3}$$

where $\Delta\phi$ is the crosstrack angle subtended by the two way beam when projected on the ground plane. The beam resolution in the intrack dimension is

$$\rho_B = \frac{h}{\cos^2\theta}\ \Delta\theta \tag{4.4}$$

See Figure 4.1 to clarify these definitions.

Scan Length

Scan length is simply the ground track distance vT traversed by the aircraft during a single integration period T where v is the ground velocity. See Figure 4.2.

Ground Track Coverage

The ground track coverage L_c is that entire length over which a radar return was observed. The coverage includes the scan length as well as the initial coverage within the beam, ie.,

$$L_c = \rho_B + vT$$

See Figure 4.2.

Ground Resolution

The ground resolution may be defined in several ways. However, for the purposes of this design effort the ground resolution is defined as an effective ground length over which radar returns have primarily contributed to the measurement as implied in Figure 4.2. It consequently emphasizes that portion of the ground track which is repeatedly in view within the beam subtended by $\Delta\theta$.

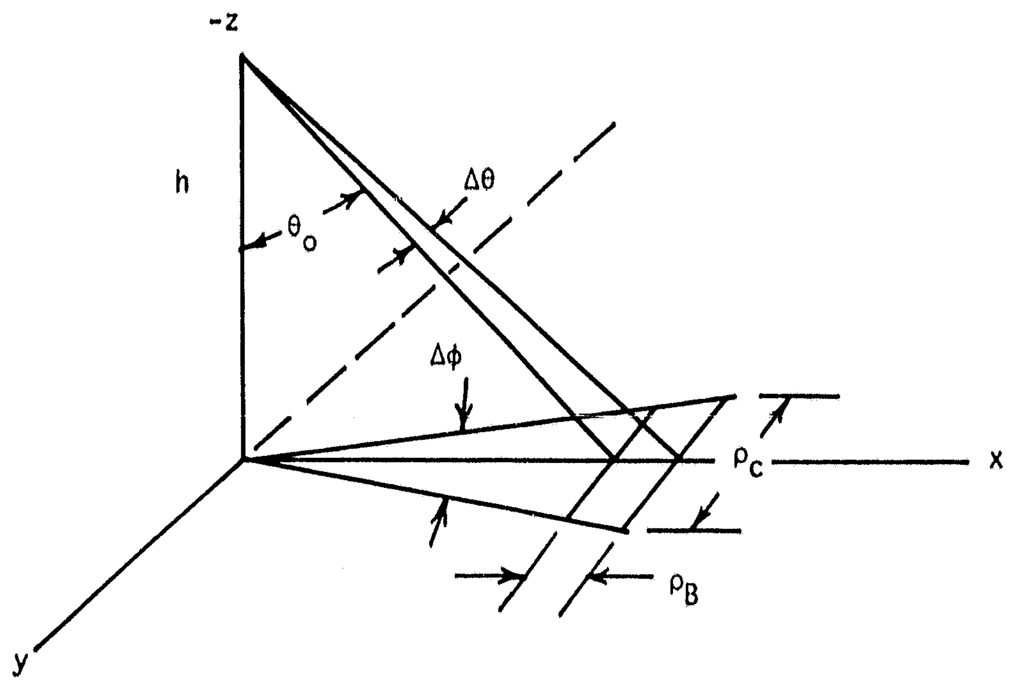


FIGURE 4.1 VARIOUS RESOLUTION PARAMETERS

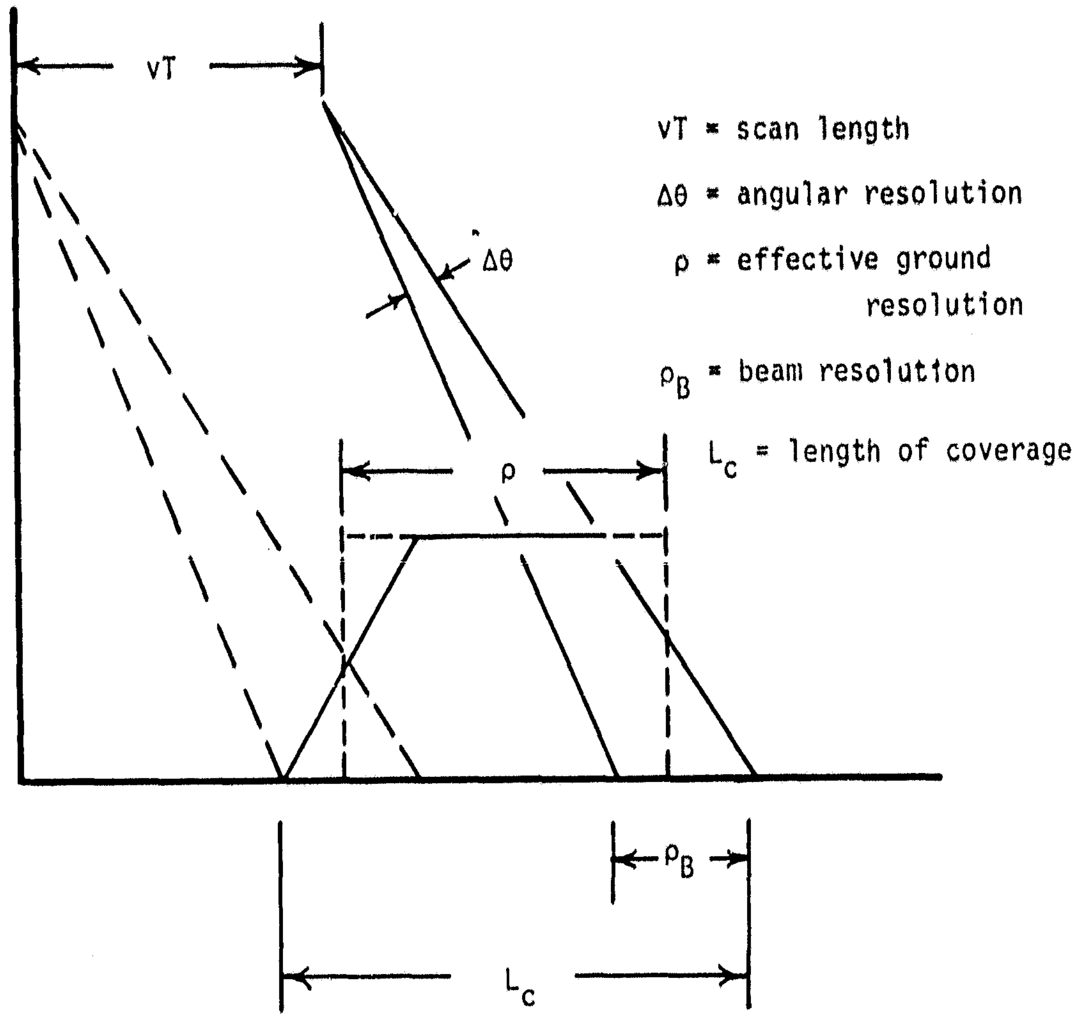

vT
$\Delta\theta$
ρ
ρ_B
L_c
vT = scan length
$\Delta\theta$ = angular resolution
ρ = effective ground resolution
ρ_B = beam resolution
L_c = length of coverage

FIGURE 4.2 VARIOUS CELL PARAMETERS

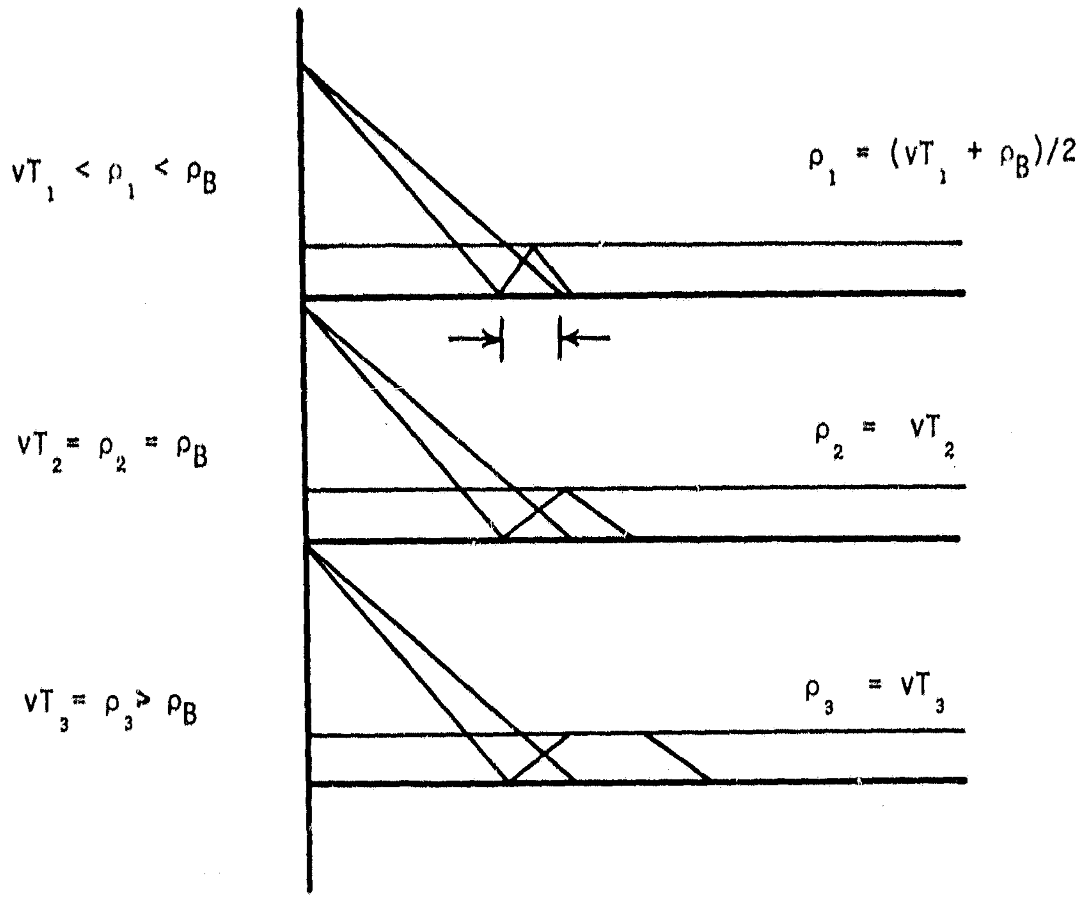


FIGURE 4.3 COMPARISON OF THE RESOLUTION PARAMETERS WHEN (a) $vT_1 < \rho_B$, (b) $vT_2 = \rho_B$ and (c) $vT_3 > \rho_B$

Three cases may be identified as illustrated in Figure 4.3. The ground resolution is therefore defined as

$$\rho = \begin{cases} \dfrac{vT + \rho_B}{2} & \text{if } vT < \rho_B \\ \rho_B & \text{if } vT = \rho_B \\ vT & \text{if } vT > \rho_B \end{cases} \tag{4.5}$$

From the above definitions an important observation can be withdrawn. When the three ground resolution cases are ordered as implied in Figure 4.3 it may be shown that

$$\frac{T_2}{T_1} \geq \frac{\rho_2}{\rho_1} \tag{4.6}$$

and

$$\frac{T_2}{T_3} = \frac{\rho_2}{\rho_3} \tag{4.7}$$

where ρ_i is the ground resolution corresponding to T_i. For a constant Doppler bandwidth these results imply the following conclusion:

Case 2 maximizes the ground resolution consistent with maximizing the precision. It is also interesting to note that Case 2 maximizes the precision for a given coverage interval L_c as demonstrated in Appendix A. In this case the design criterion requires that

$$\rho_B = vT \tag{4.8}$$

at any incident angle. This conclusion will be used in identifying appropriate design theories below.

4.3 The Theory for Constant Precision, Constant Angular Resolution and Constant Ground Resolution Designs

Among the many system designs which could be considered it is helpful to limit considerations to three basic design approaches: (1) constant precision, (2) constant angular resolution and (3) constant ground resolution. The theory for each is presented below and their characteristics are compared in a final subsection.

4.3.1 A Constant Precision Design

A constant precision design approach requires a constant BT product at each incident angle to be processed. The implication deduced from Section 4.2 is helpful in assigning B and T so as to achieve an acceptable BT product. At the smallest incident angle θ_1 the BT product may be maximized for a given coverage L_C by requiring

$$\rho_{B^1} = vT \tag{4.9}$$

Then

$$T = \frac{h\ \Delta\theta_1}{v\ \cos^2\theta_1} \tag{4.10}$$

and

$$B = 2v\ \cos\theta_1\ \Delta\theta_1/\lambda \tag{4.11}$$

The viewing window at θ_1 is therefore specified as

$$\Delta\theta_1 = \sqrt{\frac{BT\ \lambda\ \cos^2\theta_1}{2h}} \tag{4.12}$$

where BT is chosen to achieve the desired precision. When $\Delta\theta_1$ is withdrawn from equation (4.12), T and B are uniquely assigned by equations

(4.10) and (4.11), respectively. On pragmatic grounds the integration time must be constant at all viewing angles. Therefore B is also constant. As a result, the angular resolution, beam resolution, and ground resolution at the remaining view angles θ_k become

$$\Delta\theta_k = \frac{\lambda B}{2v\cos\theta_k} \tag{4.13}$$

$$\rho_{Bk} = \frac{\lambda h B}{2v\cos^3\theta_k} \tag{4.14}$$

and

$$\rho_k = \frac{\lambda h B}{4v\cos^3\theta_1} \quad \{1 + \frac{\cos^3\theta_1}{\cos^3\theta_k}\} \tag{4.15}$$

From the above results it is noted that the angular resolution is inversely proportional to $v\ \cos\theta_k$, the beam resolution is proportional to $h/v\cos^3\theta_k$ and the ground resolution is proportional to $h\ \{1 + \frac{\cos^3\theta_1}{\cos^3\theta_k}\}$

4.3.2 Constant Angular Resolution

A constant angular resolution approach requires that $\Delta\theta_k$ be constant at all viewing angles, say $\Delta\theta$. Once $\Delta\theta$ is assigned, the bandwidth at each θ_k is given by

$$B_k = \frac{2v\ \cos\theta_k\Delta\theta}{\lambda} \tag{4.16}$$

and the beam resolution by

$$\rho_{Bk} = \frac{h\Delta\theta}{\cos^2\theta_k} \tag{4.17}$$

The precision and ground resolution require a rationale to assign T. Once again it is convenient to maximize BT at the smallest incident angle for a given coverage. This requires that

$$\rho_{B_1} = vT \tag{4.18}$$

The remaining parameters then become

$$T = \frac{h\Delta\theta}{v\cos^2\theta_1} \tag{4.19}$$

$$(BT)_k = \frac{2h\cos\theta_k\,\Delta^2\theta}{\lambda\cos^2\theta_1} \tag{4.20}$$

and

$$\rho_k = \frac{h\Delta\theta}{2\cos^2\theta_1}\left\{1 + \frac{\cos^2\theta_1}{\cos^2\theta_k}\right\} \tag{4.21}$$

at each viewing angle $\theta_k > \theta_1$.

4.3.3 Constant Ground Resolution

A constant ground resolution approach requires that ρ be constant at each incident angle. With ρ specified, the precision may be maximized at each incident angle by requiring $\rho = \rho_B = vT$ in accord with Section 4.2. As a result of this imposition

$$\Delta\theta_k = \rho\cos^2\theta_k/h \tag{4.22}$$

$$T = \rho/v \tag{4.23}$$

and

$$(BT)_k = 2\rho^2 \cos^3\theta_k/\lambda\ h \tag{4.24}$$

4.4 A Comparison of the Design Approaches

To evaluate the three design approaches, the nominal design guidelines shown in Table 4.2 were employed for C band and L band systems.

The guidelines were primarily applied at the smallest incident angle and were allowed to vary at the larger incident angles depending on the design approach. The results of this evalution are shown graphically in Figures 4.4 and 4.11.

The first four graphs apply to the C band processor whereas the latter four apply to the L band processor. Each figure identifies and compares a single system performance parameter over the entire range of incident angles for the three design approaches. The graphs are parametrically identified by the design approach: CP = constant precision, CGR = constant ground resolution and CAR = constant angular resolution.

Table 4.2 Nominal Design Guidelines

Parameter	Value	Units
Aircraft velocity	150	knots
Aircraft altitude	1500	feet
Angular resolution (nominal)		
C band	3	degrees
L band	6	degrees
Ground resolution(nominal)		
C band	25	meters
L band	50	meters
Precision factor (nominal)		
C band	50	
L band	50	

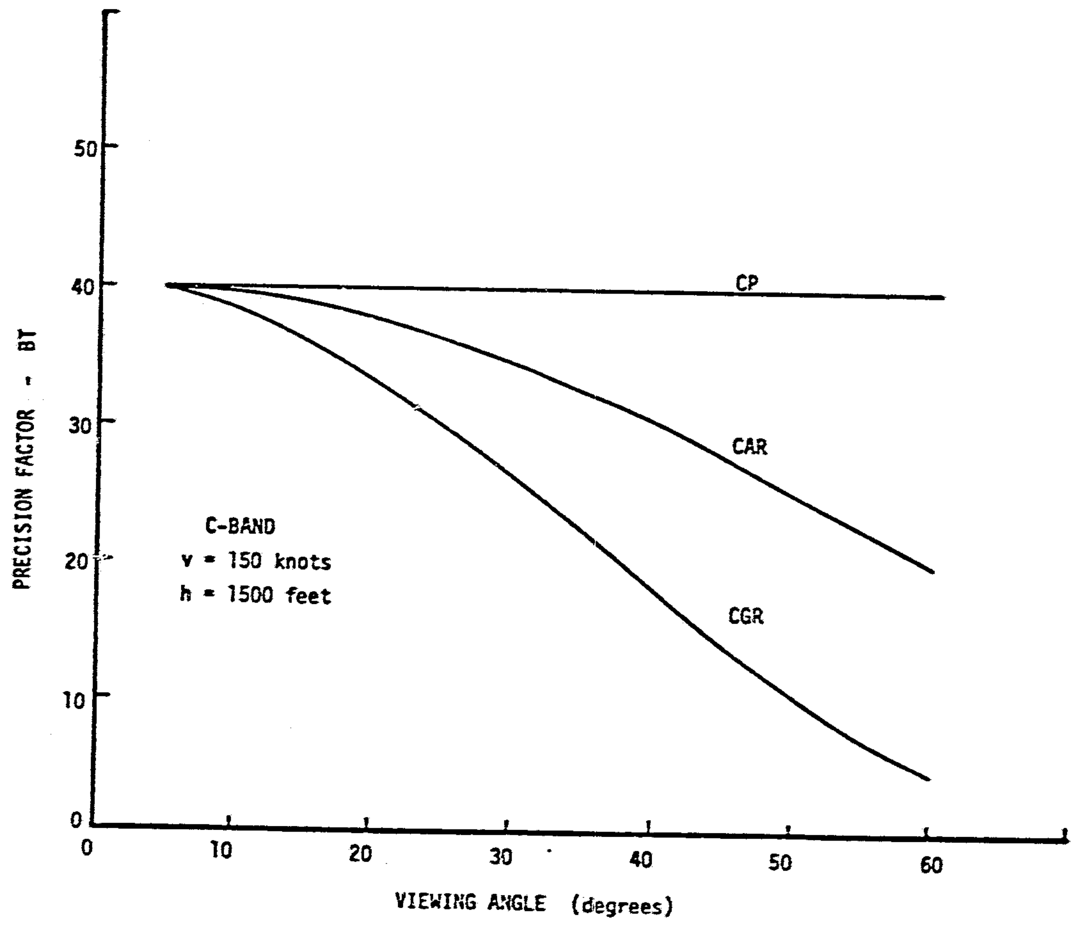


FIGURE 4.4 THE DEPENDENCE OF PROCESSING PRECISION ON VIEW ANGLE FOR THE THREE DESIGN APPROACHES

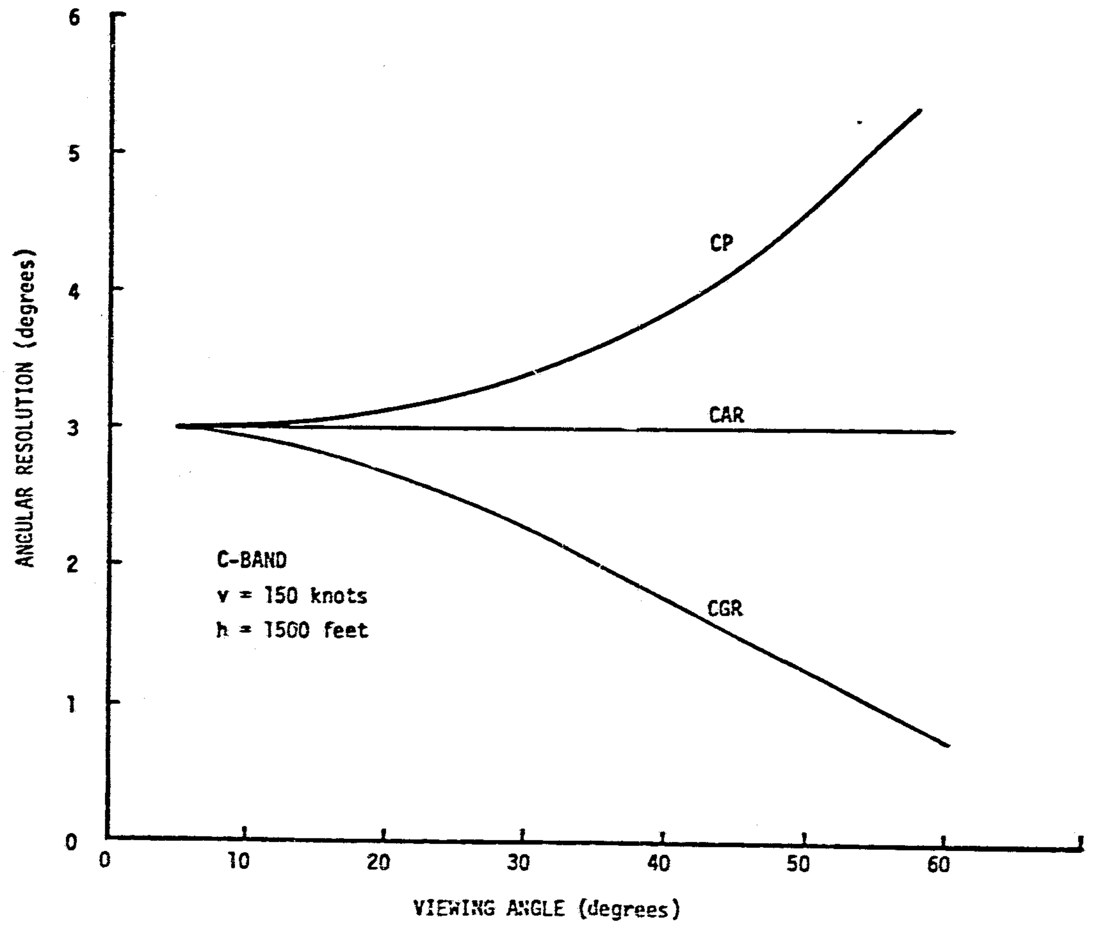


FIGURE 4.5 THE DEPENDENCE OF ANGULAR RESOLUTION ON VIEWING ANGLE FOR THE THREE DESIGN APPROACHES

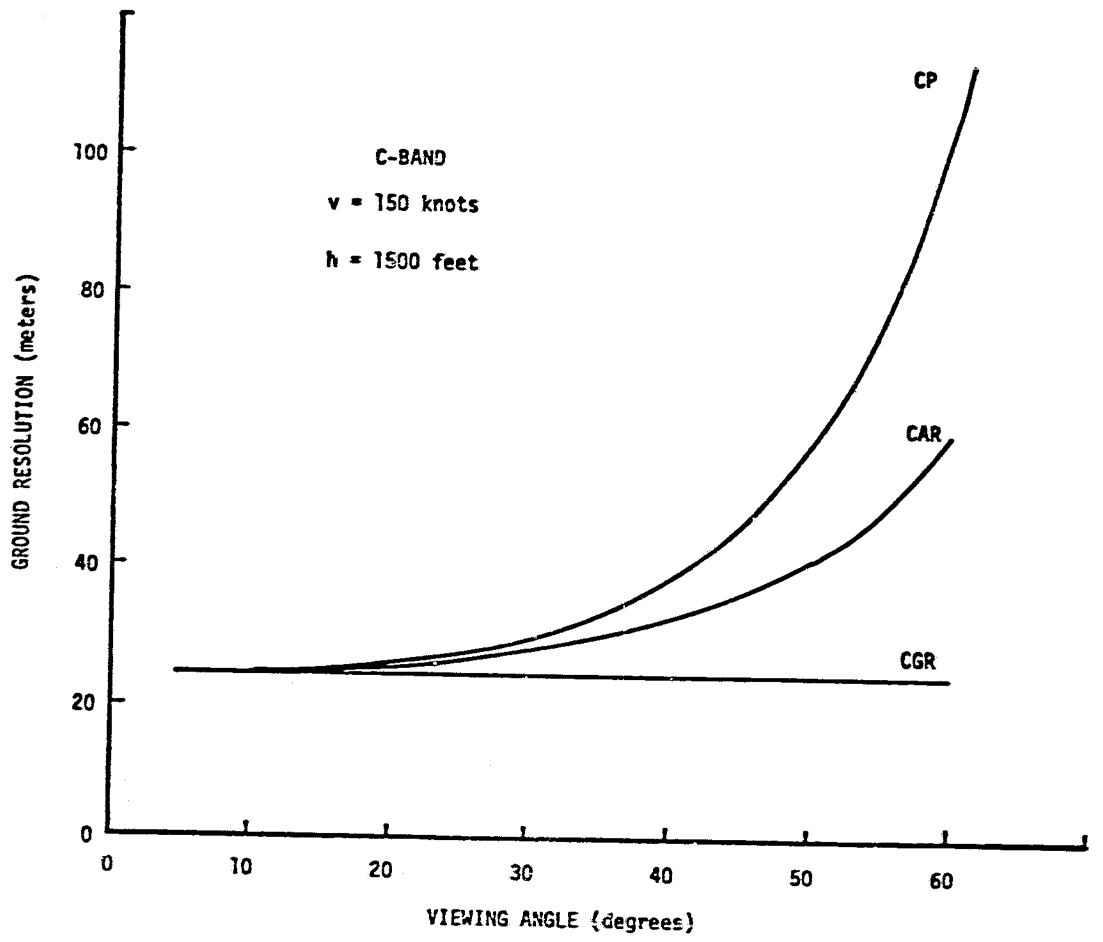


FIGURE 4.6 THE DEPENDENCE OF GROUND RESOLUTION ON VIEWING ANGLE FOR THE THREE DESIGN APPROACHES

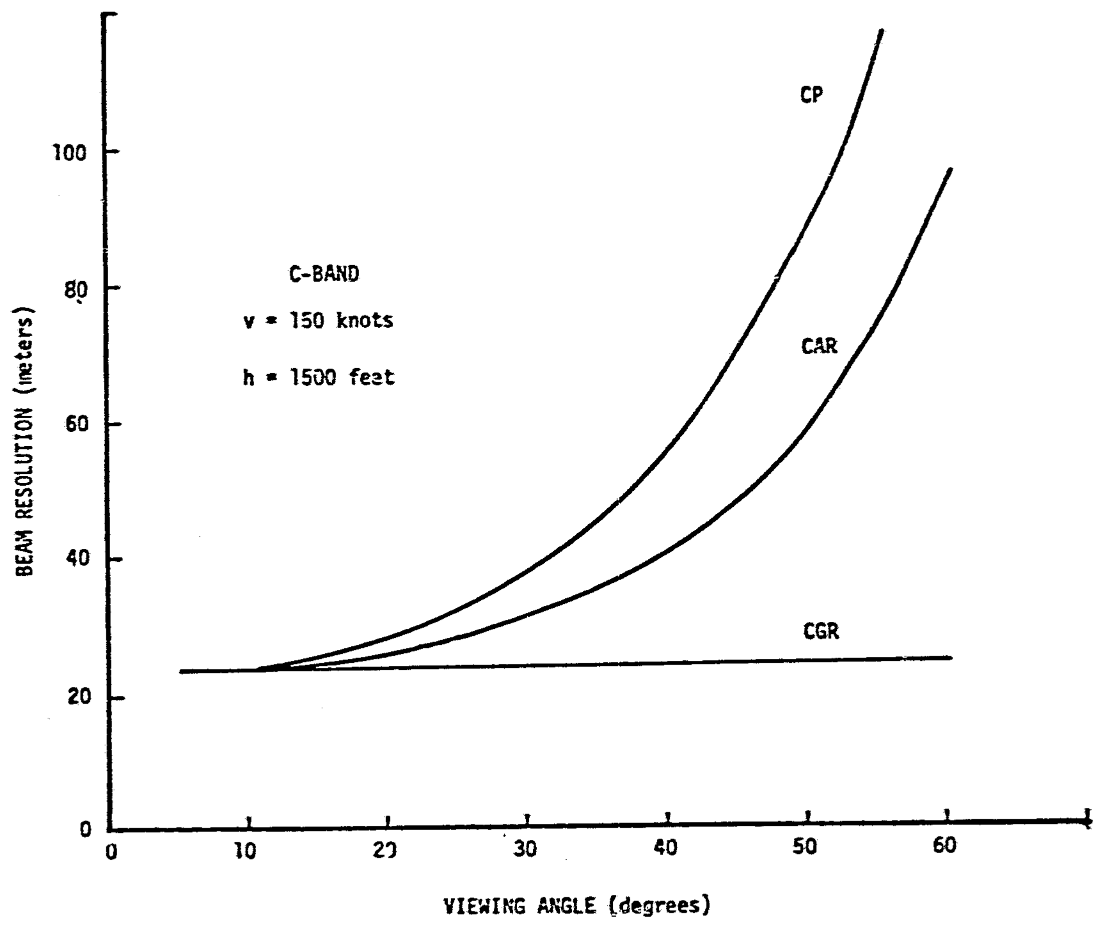


FIGURE 4.7 THE DEPENDENCE OF BEAM RESOLUTION ON VIEWING ANGLE FOR THE THREE DESIGN APPROACHES

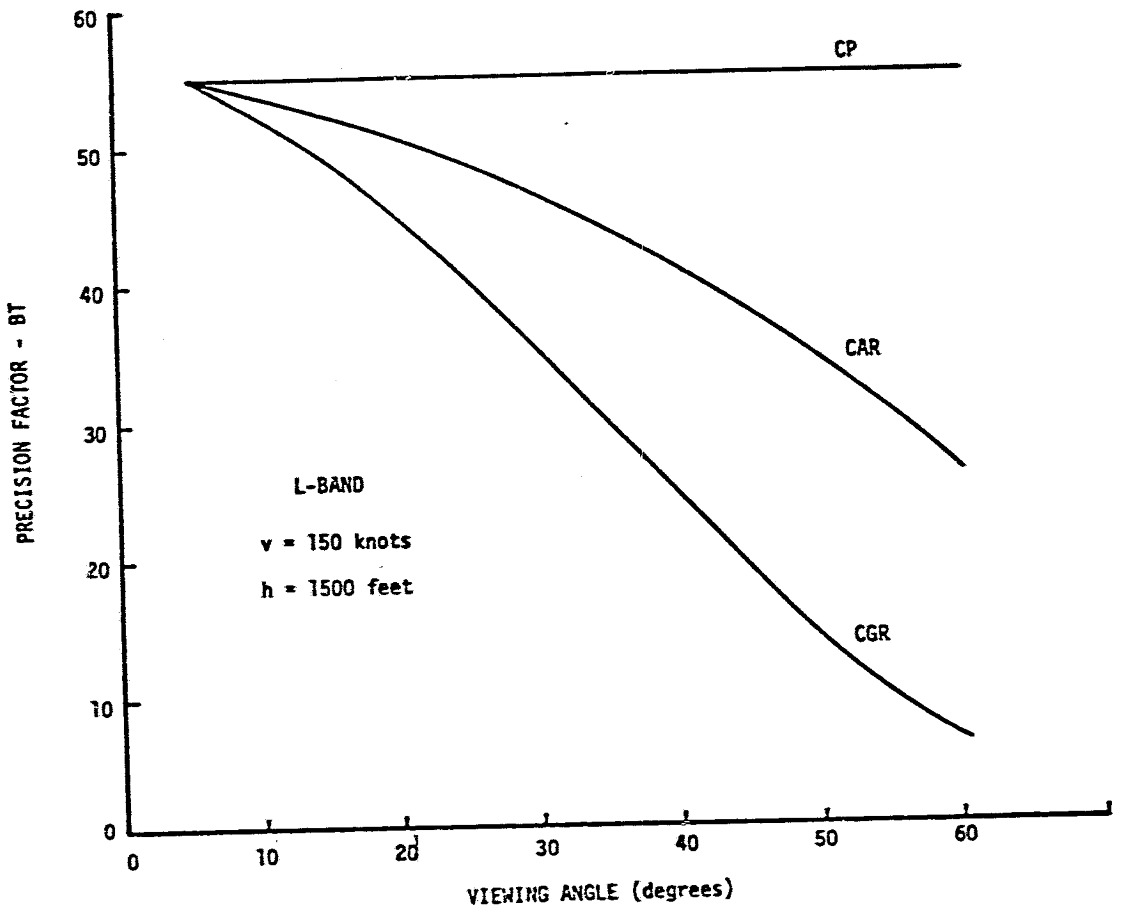


FIGURE 4.8 THE DEPENDENCE OF PROCESSING PRECISION ON VIEW ANGLE FOR THE THREE DESIGN APPROACHES

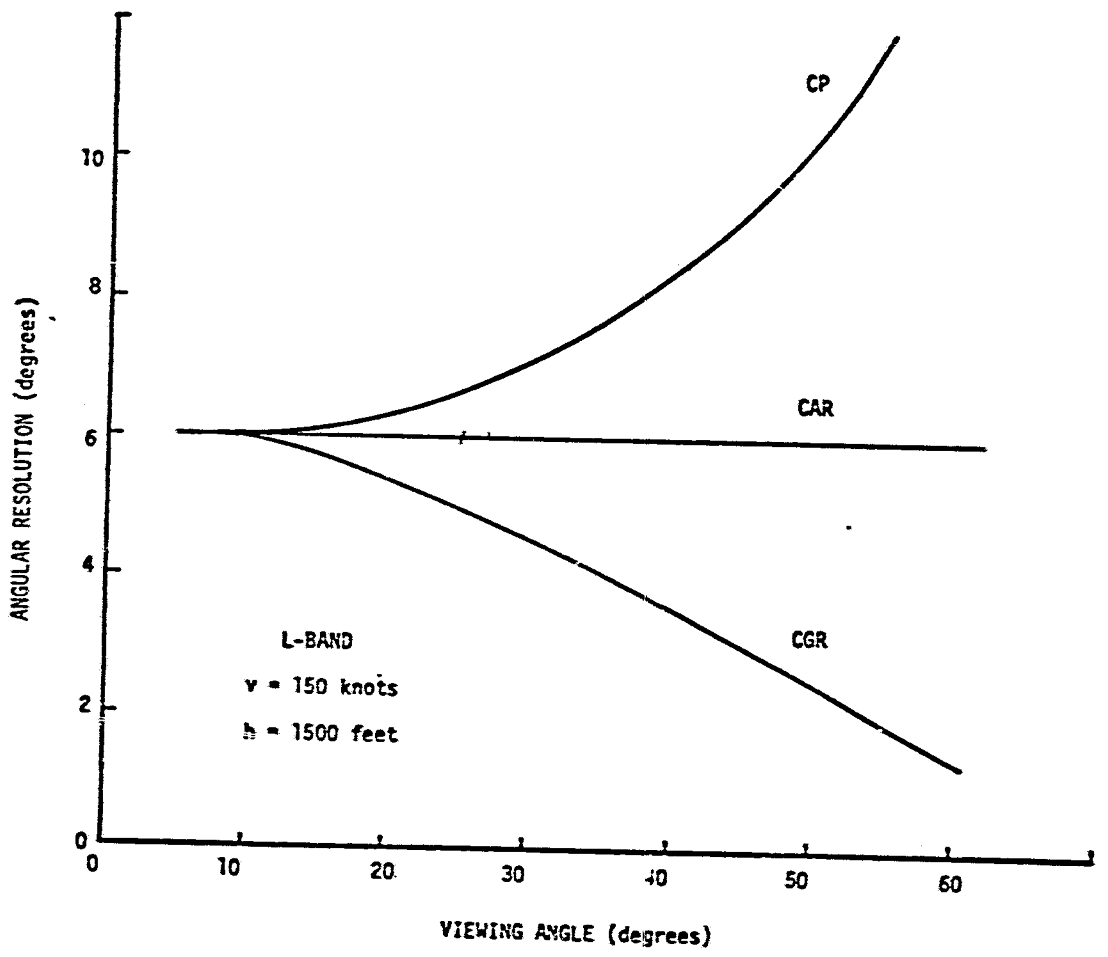


FIGURE 4.9 THE DEPENDENCE OF ANGULAR RESOLUTION ON VIEWING ANGLE FOR THE THREE DESIGN APPROACHES

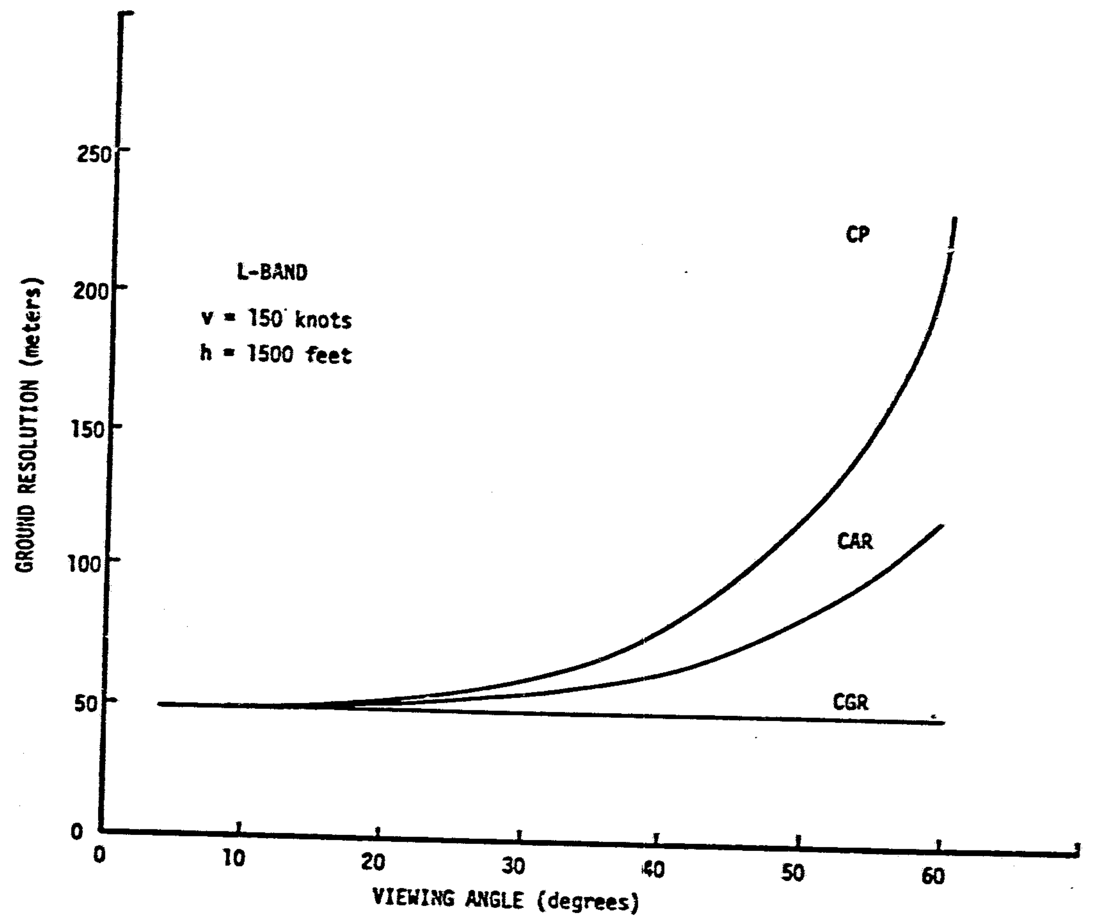


FIGURE 4.10 THE DEPENDENCE OF THE GROUND RESOLUTION ON VIEWING ANGLE FOR THE THREE DESIGN APPROACHES

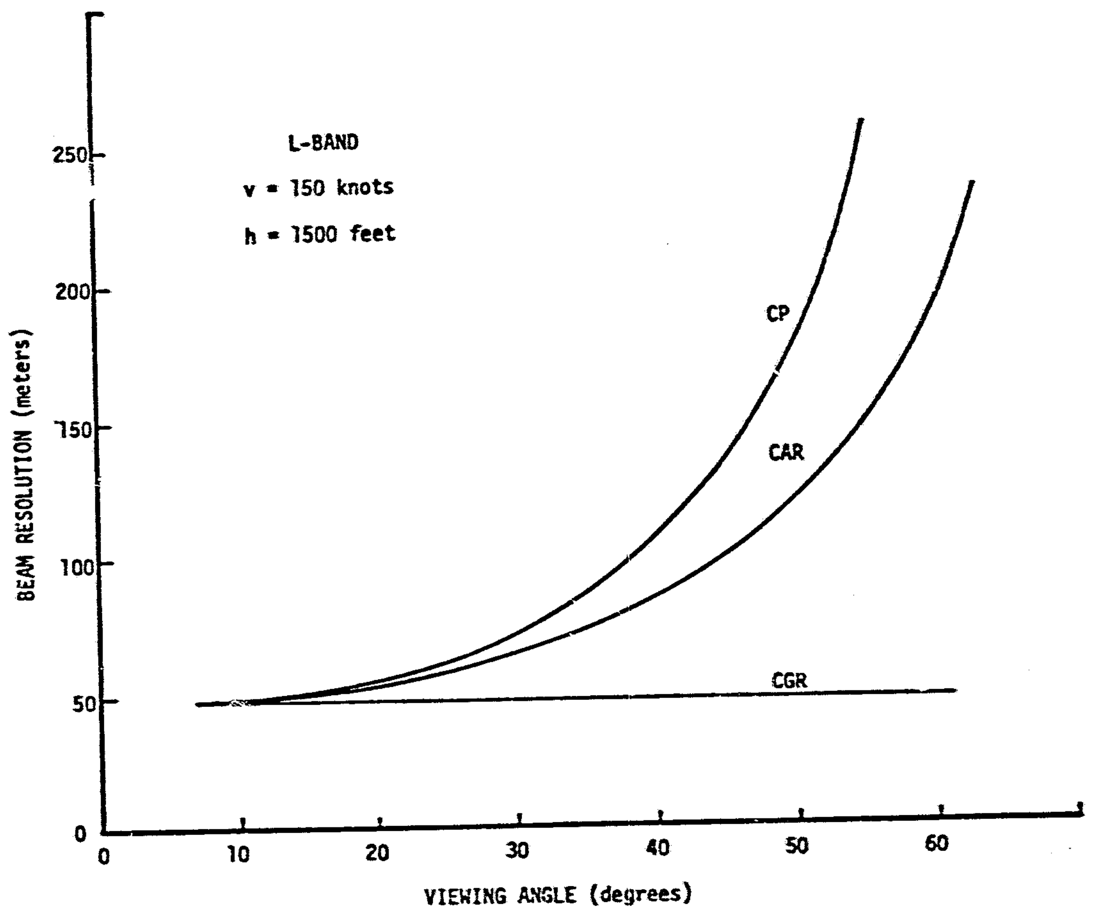


FIGURE 4.11 THE DEPENDENCE OF BEAM RESOLUTION ON VIEWING ANGLE FOR THE THREE DESIGN APPROACHES

From these graphs the following features are noted:

1). When constant precision is imposed, the angular, beam and ground resolutions degrade with incident angle; however, the degradations are only significant for angles greater than 45°.

2). When constant ground resolution is imposed, constant beam resolution is also realized. The precision, however, degrades at the larger incident angles but is useable to 50°. The angular resolution increases rapidly at the large incident angles. The very high angular resolution at the large incident angles may preclude selecting a correct pattern gain at the large incident angles when converting to $\sigma°$.

3). When constant angular resolution is imposed, the beam resolution and ground resolution degrade at large incident angles. The performance, in general, lies between the constant ground resolution and constant precision design approaches.

If a single design approach were to be selected among the three, it is apparent that the constant angular resolution approach represents a good compromise between constant precision and constant ground resolution. The constant precision and constant ground resolution designs may, however, suit some experiments better. The constant precision design is attractive in those cases where high precision is required on a single cell, particularly at the larger viewing angles. The constant precision approach may also be helpful in those cases where a large spatial average is required. The constant ground resolution approach is attractive for those applications where well metered - high resolution data are required along the intrack dimension. This design approach is consequently attractive for those targets which are highly nonhomogeneous.

Since the scatterometer processor is under software control, it is conceivable to provide an experimenter with any design option. The constant angular resolution design represents a good compromise among the approaches, however, when a single approach must be taken.

5.0 SYSTEM ARCHITECTURE AND OVERVIEW

5.1 Target and Development System Architectures

The objective of the scatterometer processing system is to provide real and post time conversion of two channels of scatterometer data, like and cross polarized signals, into σ^o estimates at eight (8) viewing angles: 5^o, 10^o, 15^o, 20^o, 30^o, 40^o, 50^o and 60^o. Processor designs were to be developed for the NASA 4.75 GHz and 1.6 GHz fan beam scatterometers. The efforts were 1) to emphasize a standardize design approach suitable for use with these scatterometers as well as future scatterometer systems and 2) to utilize design experience from the previous 13.3 GHz scatterometer processor project. An appropriate target system architecture using the CZT approach to Doppler processing and meeting the above stated objectives is illustrated in Figure 5.1. The system consists of two major subsystems, viz., the PSD estimation subsystem and the micro-processing subsystem. A number of interface units are also provided to permit control of the system, entry of data and storage of processed data. Also a special alignment generator not required during operation but helpful in aligning the CZT filtering unit prior operation is shown.

The PSD estimation subsystem has two channels to handle like and cross polarized return signals. Each channel converts the quadrature signals into discrete PSD estimates over the fore and aft Doppler spectra simultaneously. The estimation technique is based on the CZT technique which may be regarded as an analog technique of implementing the discrete Fourier transform (DFT). The detection (squaring) and accumulation (averaging) of the spectral amplitudes is performed digitally by a

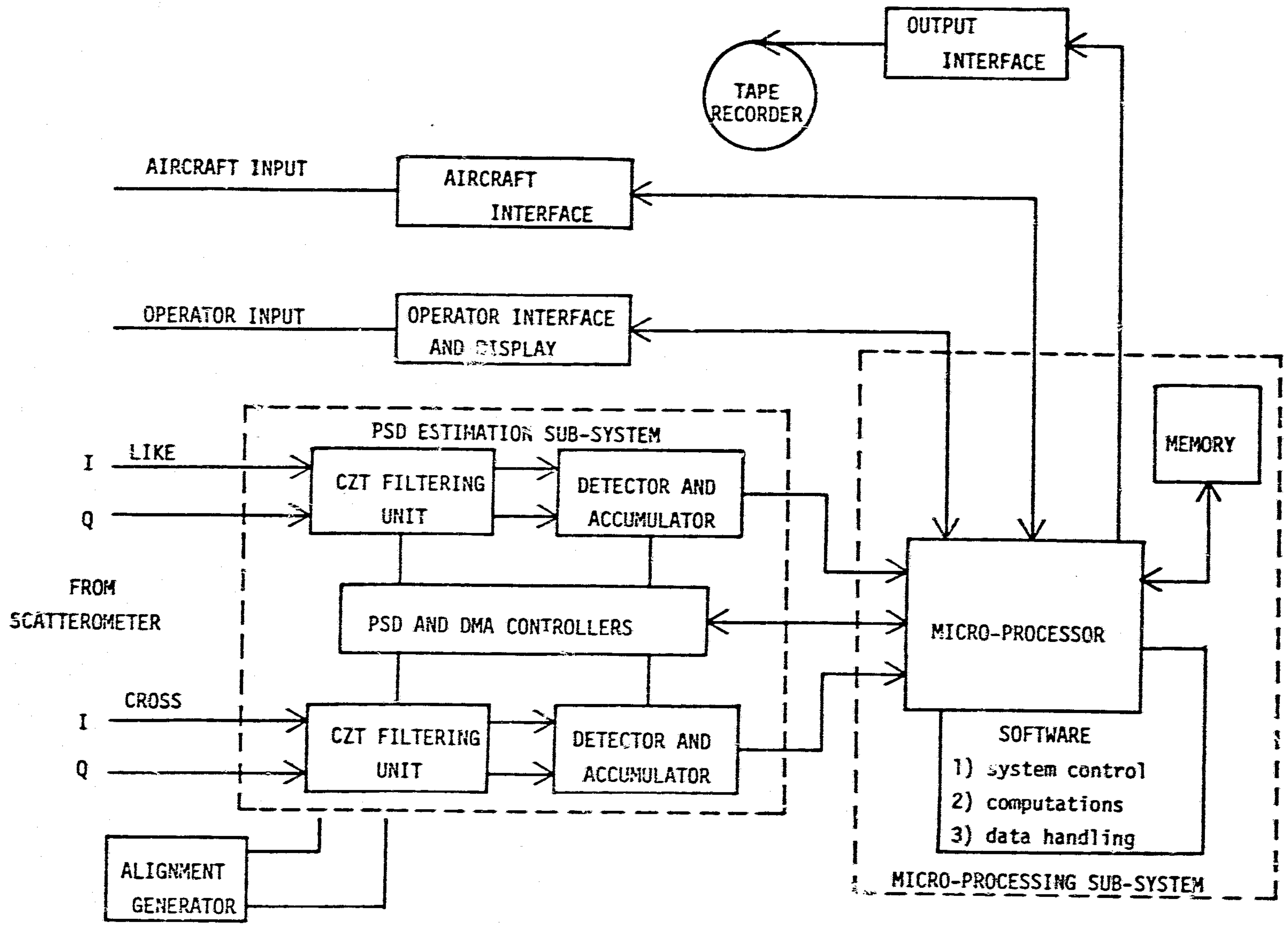


FIGURE 5.1 ARCHITECTURE OF THE TARGET SYSTEM

dedicated processor.

The micro-processing subsystem is composed of a digital micro-computer, memory and associated software. The role of the micro-processing subsystem is 1) to control the scatterometer processor through a software operating system, 2) to select appropriate PSD estimates and to use them within the radar scatterometer equation to invert for σ^0 values on the eight viewing angles and 3) to accept, store and transfer various data required by the processor or the experimenter.

Communication between the micro-processor and various peripheral systems is provided by the interface units indicated in Figure 5.1. Among these interface units is the operator interface and display. All system functions are initiated through this interface by the operator. The display is also used by the micro-processor.

The system of Figure 5.1 represents but a single architecture for the target system. It may not be the architecture of the final system but it will be close. Implied in Figure 5.1 is a single micro-processor to service both scatterometer channels. However, in view of the amounts of data and the number of computations involved, a single micro-processor may be unable to convert both channels of scatterometer to σ^0 values at eight angles without large gaps between successive ground cells. A fast floating point processor such as the Advanced Micro Computer 95/4000 may permit use of a single processor. However, it may be necessary to dedicate a micro-processor to each scatterometer channel. To make an assessment of the number of processors requires that the software design be reduced to machine coding and that the machine be specified.

In view of this uncertainty and with full realization that a complete design effort requires an iterative effort between paper design (called for in this contract) and laboratory evaluation, an engineering model which is expandable to the target system was actually designed. The architecture of the proposed design is illustrated by the block diagram of Figure 5.2. The development model is restricted to single PSD estimation channel and a single micro-processor. The software is sufficiently general to permit processing of like or cross polarized data for any transmit polarization. However, the processor must be cued externally as to which polarization channel the PSD estimation subsystem is connected. A single channel processor of this type is sufficiently simple to fully evaluate the total system design. It can be readily expanded to a two channel system, terminating in either a single micro-processor or two micro-processors. The expansion simply requires that the controller signals be routed to two channels and that simple modifications be incorporated into the software whether one or two micro-processors be required.

5.2 An Overview of the Operation of the System

As indicated above, the scatterometer processing system consists of two major subsystems together with the necessary interfaces to permit communication with various peripheral devices. The relationships among the major subsystems and interface units was shown in Figure 5.2. An alignment generator, although not required during operation, was also shown.

When the system is powered, software control of the system is assumed by the micro-processor within the so-called RESET mode. Within

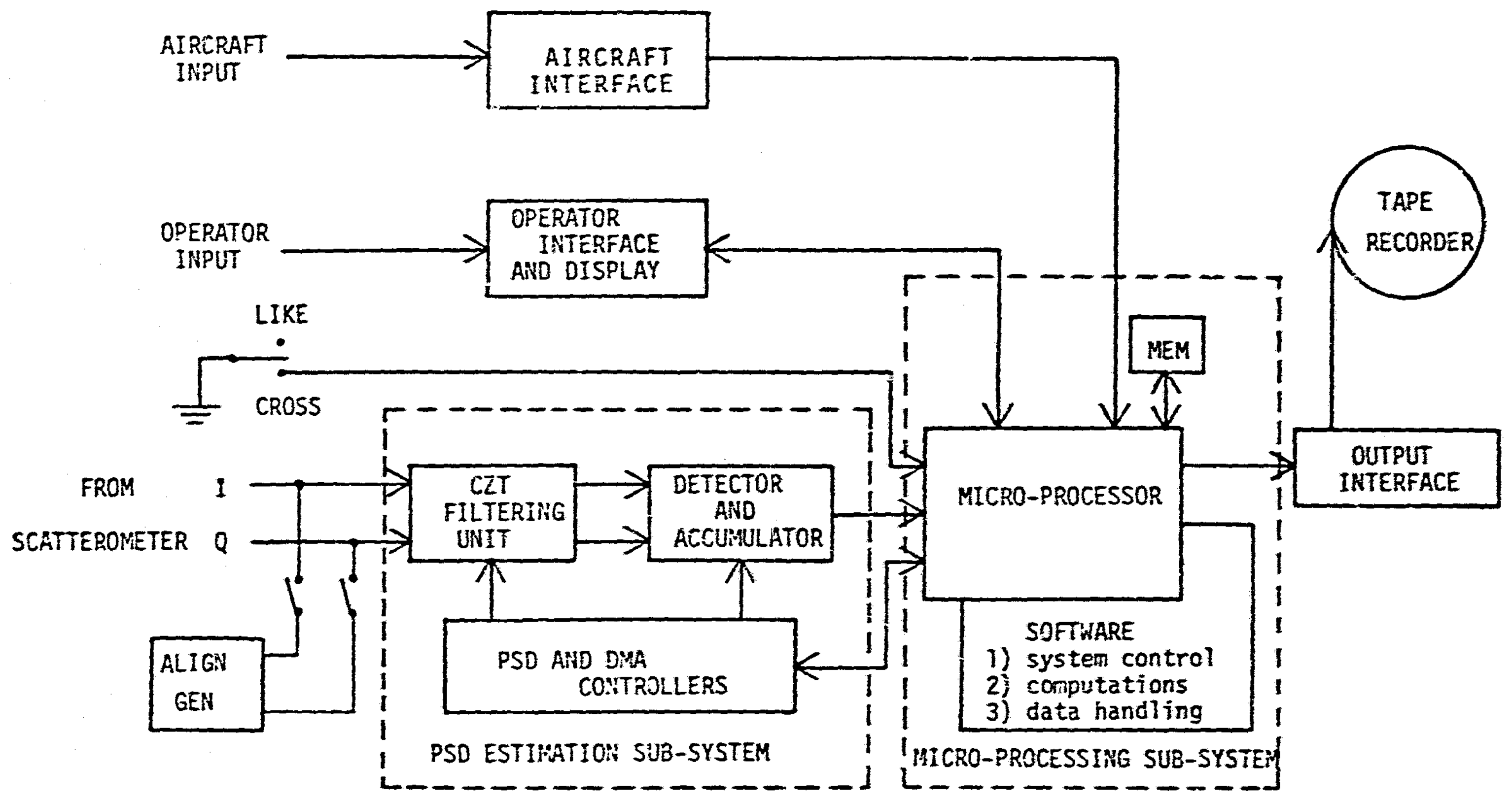


FIGURE 5.2 ARCHITECTURE OF AN ENGINEERING MODEL EXPANDABLE TO THE TARGET SYSTEM

this mode the aircraft, operator and output interface units, and the CZT filtering unit within the PSD estimation subsystem are active (see Figure 5.2). When the system is within this mode, the operator may override certain aircraft parameters arriving at the aircraft interface should they be inaccurate or missing in the aircraft data stream. From the RESET mode, scatterometer data may be processed on a flight line by entering the RUN mode.

Within the RUN mode, the software controller determines the number of 512 point sub-records to be processed to form an average return from the 512 beam resolution cells in view by the CZT filters. The number of sub-records N_R and the address to which the accumulated reserves are to be stored are transferred to the PSD controller (see Figure 5.2). Upon this initialization, the accumulator and detector are activated at the beginning of a CZT cycle. The PSD estimation subsystem then accumulates N_R estimates in each spectral channel. At the end of the N_R sub-records the detector and accumulator are halted and a DMA (direct memory access) transfer is made from the accumulator to the micro-processor memory. If the processor has not been halted by the operator, the detection and accumulation cycle is re-initiated by the micro-processor once the DMA has been completed. It should be noted that the filtering sub-section operates continuously between accumulations to avoid start up transients.

A closer look at the PSD estimation subsystem will indicate that this subsystem filters the fore and aft Doppler spectra of the radar return to form estimates of the return power is 512 parallel spectral channels. Of these channels, 256 are available to characterize the fore spectrum and 255 the aft spectrum. The remaining channel monitors the return from the nadir point (this return is suppressed by the radar and the processor). A sliding CZT algorithm, as discussed in Section 3.5, is employed to form repeated estimates of the power return within each channel. Several estimates are summed to form an improved estimate of the average power.

The format of the summed spectral estimates in the 512 channels is illustrated in Figure 5.3. When the forward CZT is formed on the complex signal x + jy, the aft spectrum appears in the first 257 accumulation bins (channels) and the fore spectrum in reverse order in the latter 255 accumulation bins. Some of the spectral channels among the 512 channels are reserved for the calibration and polarization tones. The effective bandwidth of each channel is given by $B = f_s/512$ where f_s is the sampling frequency. The frequency resolution, i.e., the separation between spectral estimates is also equal to B. The normalized frequency response of each filter in dB is illustrated in Figure 5.4. The filter efficiency to the first sidelobes is 90.3% and through the first sidelobes is 95.5%*. The effective bandwidth is also equivalent to the width of the mainlobe.

The average spectral estimates together with calibration and polarization tone levels are transferred from the PSD estimation subsystem to the micro-processing subsystem through a DMA process initiated by the

*It is possible to increase the mainlobe efficiency by weighting the tap points on the CZT transversal filter. Such a device is available. However, this design is not recommended since 1) the precision will be reduced by a factor of two (the adjacent channel outputs are highly correlated) and 2) the S/N ratio referred to the output of the weighted transversal filter degrades by a factor of two (the noise is primarily governed by the post amplifier and signal output is reduced when weighting is used).

W = BANDWIDTH CORRESPONDING TO DESIRED ANGULAR RESOLUTION

B = FREQUENCY RESOLUTION AND EFFECTIVE BANDWIDTH

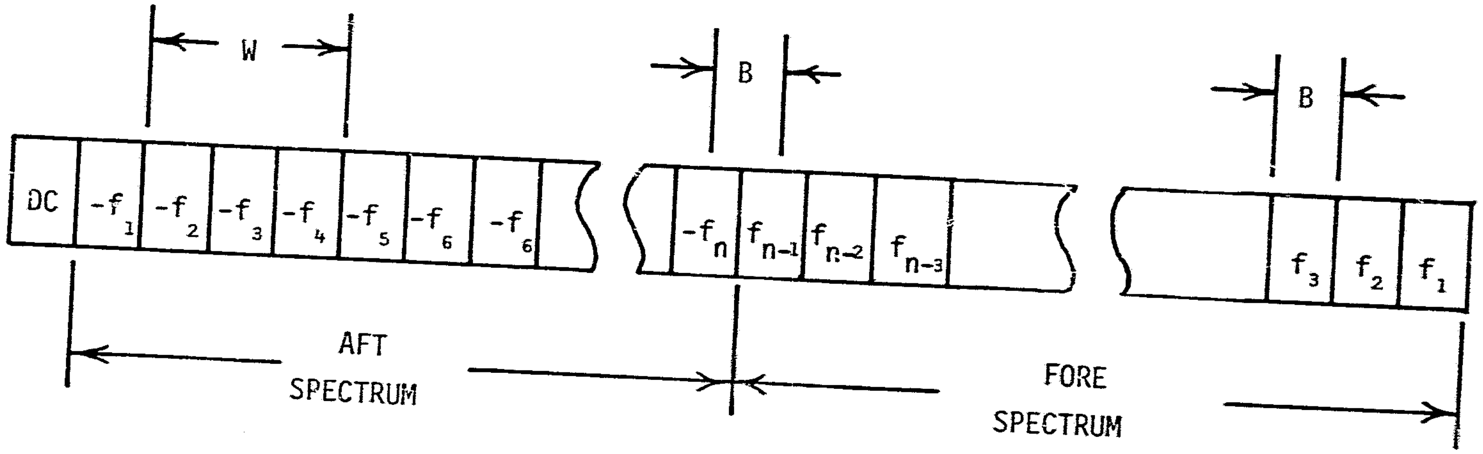


FIGURE 5.3 SPECTRAL DATA FORMAT AND RELATED PARAMETERS

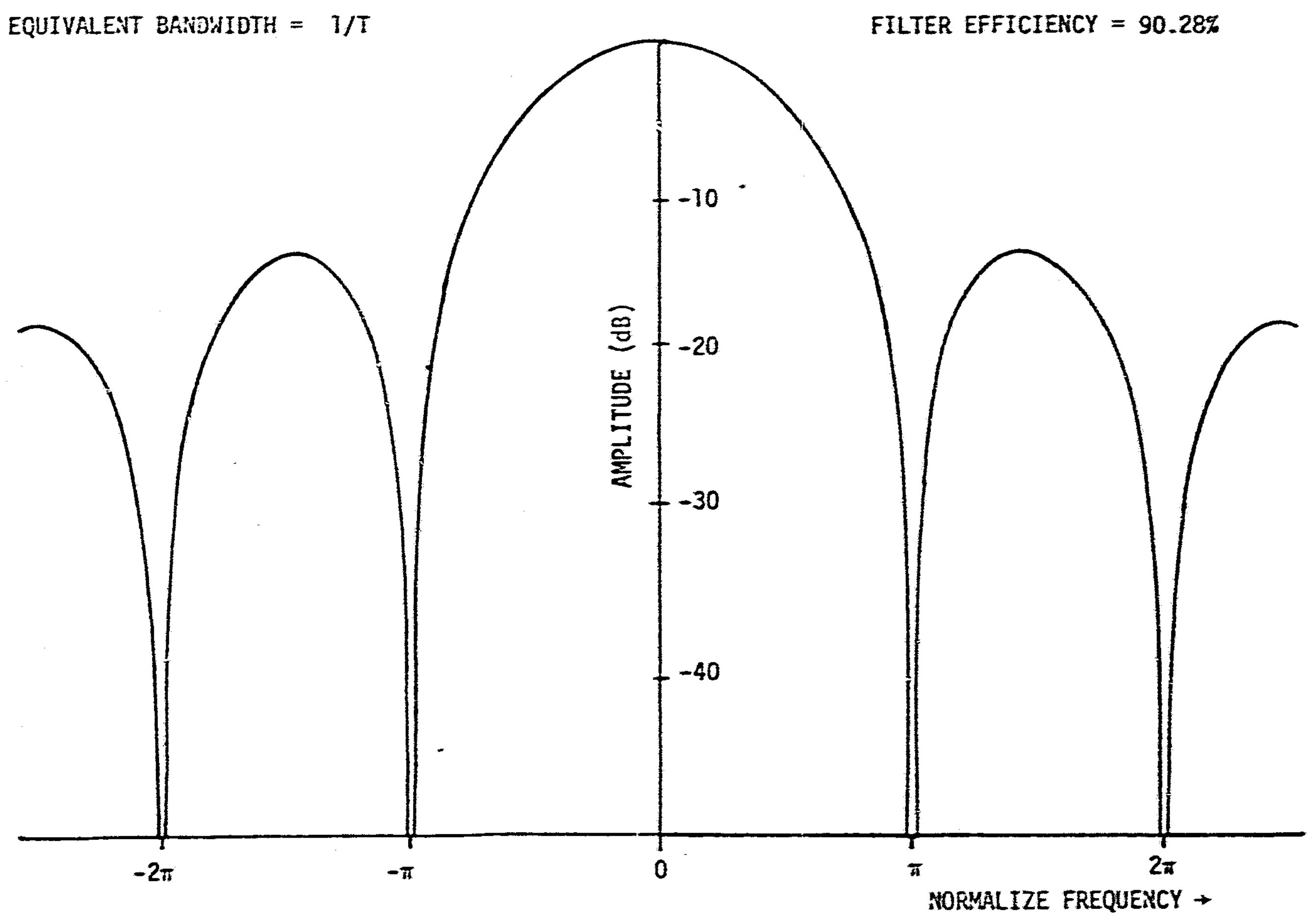


FIGURE 5.4 FILTER POWER SPECTRAL RESPONSE

PSD controller. Once the detector and accumulator are re-initiated, the micro-processor, using data from the aircraft interface together with invariant calibration constants stored in ROMs (Read Only Memories), converts the spectral and calibration data to σ^{0} estimates at the required eight viewing angles. Adjacent spectral estimates are summed about each viewing angle to form a total return within the desired angular resolution. The spectral lines are chosen dynamically to track the specified viewing angle.

The processed scatterometer data and other parameters are stored in an array of the micro-processor memory for each of the viewing angles. The σ^{0} estimates at the eight angles are stored in memory in an askewed fashion to provide near collocation of the returns on a single cell. When the re-ordered data is available on a single cell at all angles, it is written out to the output interface which in turn transfers it to magnetic tape. The transfer of the data continues until the operator halts the processor. When halted, the processor places an end of file indicator within the output array, transfers the partially filled array to tape and enters the RESET mode to await instructions from the operator. At the beginning of each accumulation cycle, appropriate parameters are withdrawn from the aircraft data channel for use in the computations and for transmittal to the output tape.

6.0 Software Development For C-Band/L-Band Real-Time Radar Data Processor

6.1 Background

During 1979, under NASA Contract NAS9-15311, the analysis and design of a 'real-time' software algorithm for processing fan-beam radar data was completed. The product of the 1979 work was a newtechnique for producing aligned, digital scattering coefficient values for up to eight aft viewing angles at the same time the raw data was being acquired. The increased capability of this data reduction technique was due mainly to the use of a hardware chirp Z-transform (CZT) to simultaneously produce all the filtered frequency domain data from the analog I and Q channel inputs. A previous hardware processor used individual analog filters which were sampled sequentially. This processor was designed to perform only a quick look, data validation function, rather than provide fully reduced cross section data. The sequential filtering technique was inadequate for full real-time processing in that it could not provide adequate along track coverage while maintaining an acceptable time bandwidth product [1].

The current production techniques used for processing radar data to scattering coefficients utilize several stages of computer processing, all of which require expensive digital Fourier transforms to convert the data from the time domain to the frequency domain. The objective of the effort during this contract period was to demonstrate that this entire process could be accomplished with micro-processor technology along with a relatively inexpensive CCD transversal filter to accomplish the normally expensive domain transformation of the input data.

6.2 Software Algorithm

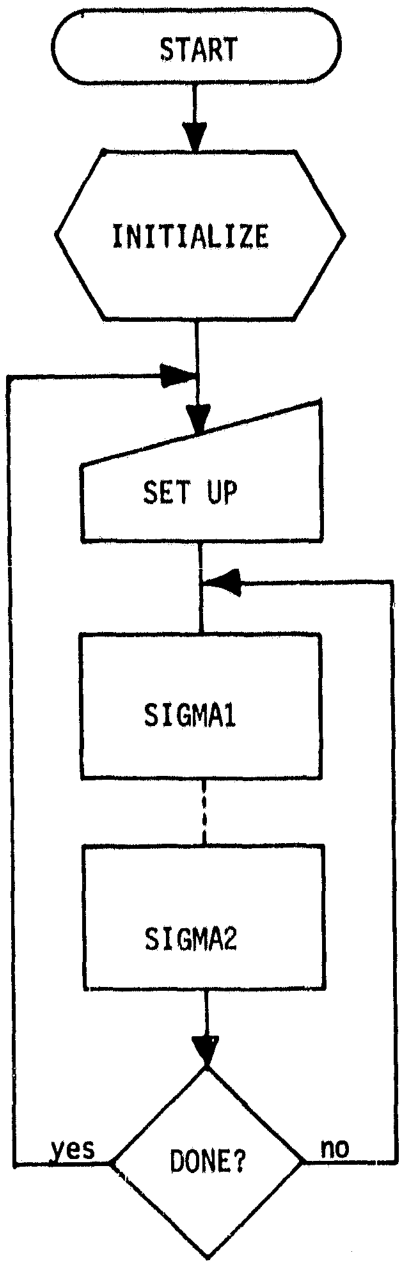
6.2.1 General Concept

The computational sequence used for sigma-zero calculations is essentially the same as that described in Section 8.0 of reference [1]. Some minor changes were made in the way some of the individual parameters are developed, and in the order and refresh rate of the aircraft data input. The most significant difference in the overall system is in the number of options available to the operator when setting the mode of operation.

6.2.2 System Initialization and Set-Up

In its simplest form the system logic is as illustrated in Figure 6.1. The initialize task opens the I/O port for the CRT, the serial port for the Bi-Phase L, and sets the CZT board for mapping the frequency domain data to micro-processor memory. Also initialized are the NERDAS port and the Interrupt Controller on the SBC 80/20. Table 6.1 defines the I/O Ports used by the system.

After initilization, the software begins a series of queries to the operator to determine the exact set-up and run mode options to be used. The system software is designed to process either C-Band or



Initialize I/O ports, CZT-board, interrupts.

Acquire processing variables, set optional parameters.

Read NERDAS, set CZT-board, evaluate T_O' values.

Read CZT-board, evaluate power ratio and T_O values buffer and output data to Bi-phase-L.

FIGURE 6.1 Overall System Structure.

TABLE 6.1

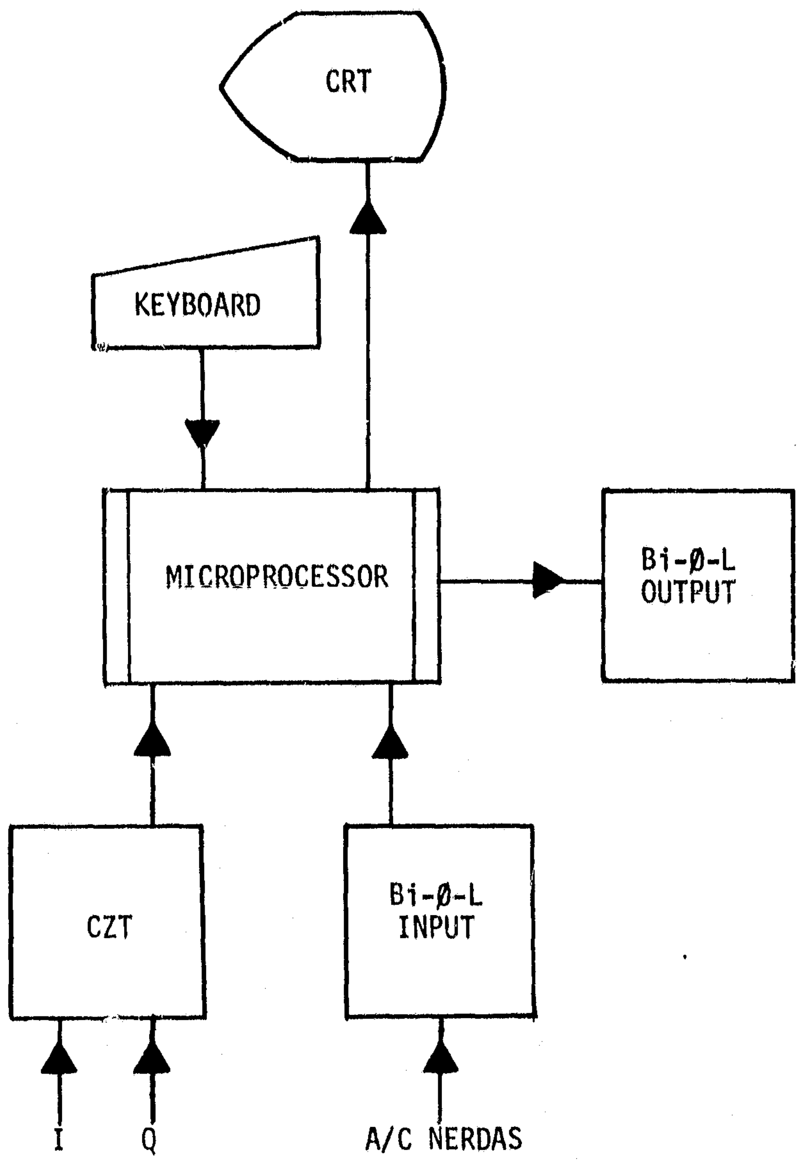
I/O PORTS USED BY NASA-CZT PROCESSOR

PORT ADDR (HEX)	LOCATION (BOARD)	FUNCTION
08	CZT BOARD	Load NBR RCDS
09	CZT BOARD	Begin DMA Transfer
0A	CZT BOARD	DMA ADDR (LSB)
0B	CZT BOARD	DMA ADDR (MSB)
CC	SBC 116	CRT Data, I/O
CD	SBC 116	USRT Control Port
D8	SBC 80/20	Interrupt Controller, Control
D9	SBC 80/20	Interrupt Controller, Control
E4	SBC 80/20	Bi-phase-L, Data Port A
E6	SBC 80/20	Bi-phase-L, Data Port C
E7	SBC 80/20	Bi-phase-L, Control PI/O
EC	SBC 80/20	NERDAS, Data IN
ED	SBC 80/20	USRT Control Port

L-Band input data of any desired polarization combination. Considerable flexibility has been given to the operator regarding use of system constants and aircraft data inputs. Further, the operator is allowed to change the ground cell resolution and thus may make interpretive analysis of resolution effects on sigma-zero for repeated passes through the same data set.

Figure 6.2 illustrates the general system layout from the operator's point of view. System communication and control is provided through the keyboard/CRT. One type of input data may be selected and processed; e.g., vertical, cross-polarized, L-band. The system may be operated in various combinations of 'Open-Loop' or 'Timed' modes. During 'Open-Loop' operations, no defined start time is given and no defined stop time is given. The system begins processing on permission of the operator and continues until the operator gives the stop command. In the 'Timed' mode the system is given a data set start time; e.g., 14:15:21, and a data set length in seconds. The system begins processing on permission of the operator and on detection of the desired start time in the NERDAS Bi-phase-L input frame. Processing continues until the specified number of seconds of data have been acquired.

Specific options given the operator during operation vary according to whether the first data set is about to be taken or subsequent sets are being acquired. The Flow charts in Appendix A give complete details on all available options and exactly how they are provided. Some highlights of the system flexibility are:



Polariz: (HH/HV/VV/VH)
Band: (L/C)

FIGURE 6.2 General System Layout, Real Time Processor.

a. Band {L/C}, select L or C
b. Polarization {HH/HV/VV/VH}, select one combination
c. Cell Resolution Over-ride {YES/NO}
d. System Constant Over-ride {YES/NO}
e. NERDAS DATA Over-ride {YES/NO}
   If 'YES':
      ALTITUDE Over-ride {YES/NO}
      DRIFT Over-ride {YES/NO}
      ROLL Over-ride {YES/NO}
      PITCH Over-ride {YES/NO}
      VELOCITY Over-ride {YES/NO}
f. Start Time Select {YES/NO}
g. Run Time Select {YES/NO}
h. Display Set-up Data {YES/NO}

On the second and subsequent data sets the operator may choose whether the above set-up is retained or whether a new set-up is used. All necessary data for calculating the sigma-zero values is requested from the operator during the set-up phase of the program.

As each operation is initiated, appropriate pointer settings are computed for accessing the correct beamwidth, wavelength, filter size, calibration frequency, noise frequency band, antenna gain table, roll-off function, processing constant, and aircraft data. In addition, flags are set (which are later put in the output data frame) that indicate to the data user which options were selected and which over-rides were used. Finally, after the start and stop times are set (if selected) and the option to display the set-up has been made, the operator is given the option to start taking data. If the operator response is 'Y', the system begins reading and processing the raw input data. As each set is processed it is placed in the output data buffer for transfer to the Bi-phase-L output port.

To ease the formatting burden, especially in the set-up module, the main driver program was coded in FORTRAN, using an INTEL MDS230 to enter and prepare the source code for the INTEL FORT80 compiler. Although the FORTRAN was used extensively for internal data formatting, all I/O is handled by special device service routines, each written in assembler language.

In the set-up module all mathematical expression were accomplished using the INTEL floating point software library routines. Since speed in this portion of the system was not critical, the time saved in coding was considered a good trade-off for additional core-usage and slower execution. However, all floating-point evaluations in the data processing and output modules are done using the AMC 95/6011 hardware arithmetic unit. Special device service routines were written in assembler language to perform all the required operations. Appendix D lists all AM9511 routines and defines their particular function.

6.2.3 'RUN' Mode of Operation

After all set-up data has been acquired, the 'RUN' mode is initiated by an operator 'Y' response to the system query. The 'RUN' mode reads NERDAS, sets integration time and starts integration by the CZT-board. Initial data is processed to calculate $\sigma^{0\prime}$ values for each of the eight viewing angles.

6.2.3.1 Calculating $\sigma^{0\prime}$

The expression which must be evaluated for each of the eight viewing angles is

$$\sigma^0{}_i = \frac{(4\pi)^3}{\lambda^2}\,\frac{CL}{K}\,\frac{Zw(fdci)}{GG(\theta'_{ii})}\,\frac{R^4(\theta Li)}{A(\theta_{Li})}\,\frac{PR(\theta Di)}{P_T} \qquad (6.1)$$

where: $\sigma^0{}_i$	= estimated scattering coefficient.
λ	= wavelength.
C_L	= cable loss term.
K	= system constant.
$Zw(fdc_i)$	= system roll-off, function of doppler frequency, fdc_i, for each filter center.
$GG(\theta_{Li})$	= antenna gain, function of viewing angle through the antenna.
$R^4(\theta_{Li})$	= target cell range, function of viewing angle.
$A(\theta_{Li})$	= cell area, also function of viewing angle.
$PR(\theta_{Di})$	= received power, function of each doppler angle.
P_T	= transmitted power.
i	= index for viewing angle, i=1, 8.

Note that after integration is started, all the terms in the above expression can be evaluated except the power ratio, P_R/P_T. After arranging the equation so that

$$\sigma^0{}_i = \sigma^{0\prime}{}_i (P_{Ri}/P_T) \qquad (6.2)$$

where

$$\sigma^{0\prime}{}_i = \frac{(4\pi)^3}{\lambda^2} \frac{C_L}{K} \frac{Z_W}{GG} \frac{R^4}{A} \qquad (6.3)$$

it can be seen that $\sigma^{0\prime}$ may be evaluated while the CZT-band is performing the integration. This is done in the SIGMA1 code module for each of the eight viewing angles. The value $(4\pi)^3/\lambda^2$ is a stored-constant value, one for each band. Similarly, C_L/K are stored values. However, there are eight values in all, four for each band. The roll-off, Z_W, is calculated using an appropriate expression for the band and polarization being processed. The antenna gain, GG, is acquired by table look-up using an appropriate table of values for the band and polarization in use. The L-band tables have values for angles ranging over -70 to +10 degrees, while the C-band tables range from -60 to 0 degrees.

The R^4/A term is evaluated as two separate values, R^4 and A. The range, R, is evaluated using the expression

$$R_i = H/\cos\theta_i \tag{6.4}$$

where H = altitude, and
θ_i = viewing angle

The above expression is derived from the system geometry shown in Figure 6.3. The range expression is not exact, but is sufficiently accurate as jusified in Reference [1], Section 8.0. The area term, A, is evaluated using the expression

$$A = W'(Y_2 - Y_1)/\cos\phi \tag{6.5}$$

where

W' = cell width, function of altitude, beamwidth, viewing angles and aircraft roll.

Y_1 = Y-coordinate of doppler contour, lower frequency.

Y_2 = Y-coordinate of doppler contour, upper frequency.

ϕ = aircraft drift angle.

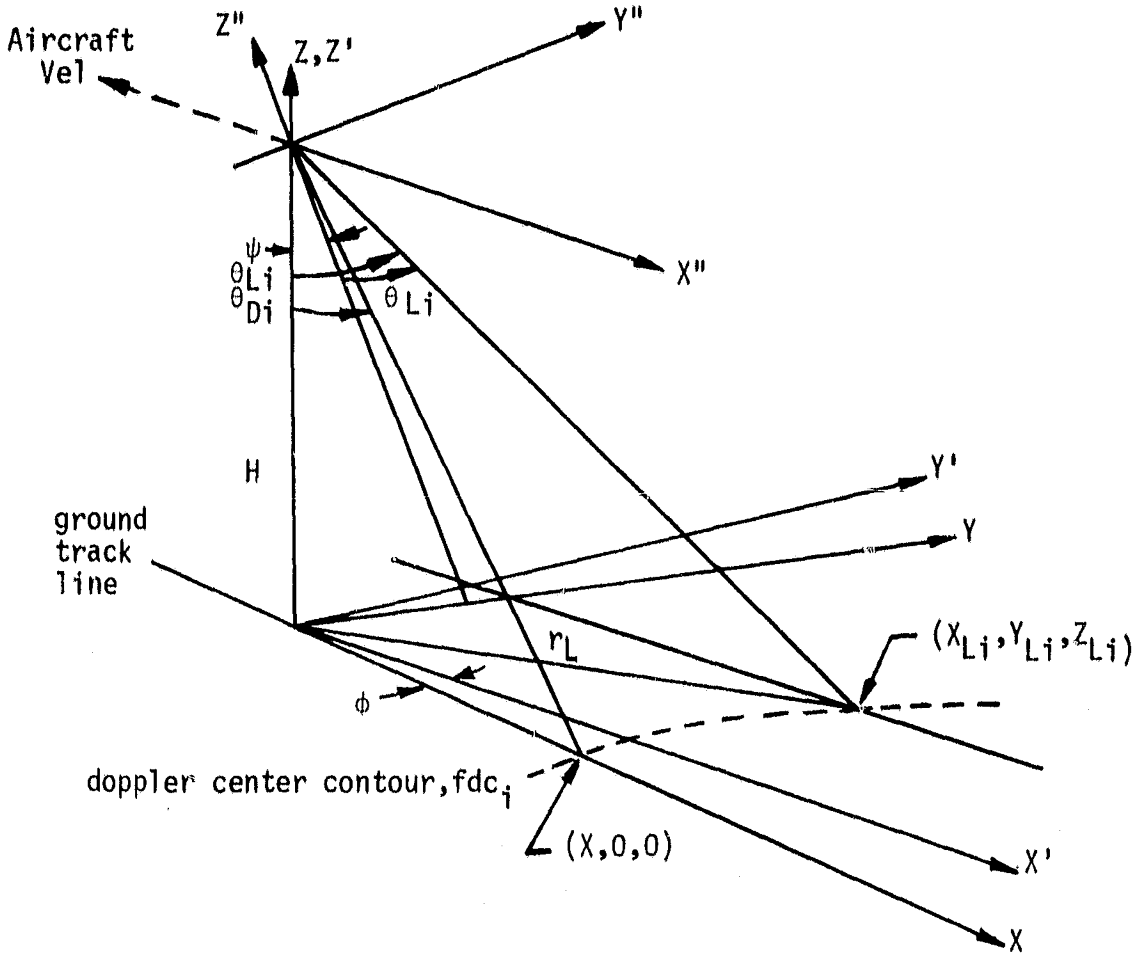


FIGURE 6.3 System Geometry.

Detail justification for the above expression is available in References [7] and [8]. The software encoding of the above expression requires the upper and lower Doppler frequencies that define the cell boundary; therefore, they are evaluated before area, A. The upper and lower Doppler frequency defining each cell require in turn, each cell center coordinate, Doppler angles and bandwidth.

The cell center coordinates are calculated using the two coordinate transformation vectors

$$\begin{vmatrix} X' \\ Y' \\ Z \end{vmatrix} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & \cos\Psi & \sin\Psi \\ 0 & -\sin\Psi & \cos\Psi \end{vmatrix} \begin{vmatrix} X'' \\ Y'' \\ Z'' \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ H \end{vmatrix} \tag{6.6}$$

and

$$\begin{vmatrix} X \\ Y \\ Z \end{vmatrix} = \begin{vmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{vmatrix} \begin{vmatrix} X' \\ Y' \\ Z' \end{vmatrix} \tag{6.7}$$

where Ψ = aircraft roll angle and ϕ = aircraft drift angle.

From the above, the viewing point coordinates in Figure 6.4 are

$$X_i = (-H/\cos\Psi)\tan\theta_{Li}{}'\cos\phi + H\tan\Psi\sin\phi \tag{6.8}$$

and

$$Y_i = (-H/\cos\Psi)\tan\theta_{Li}{}'\sin\phi - H\tan\Psi\cos\phi \tag{6.9}$$

where $\tan\theta'_{Li} = -(\tan^2\theta_{Li} - \tan^2\Psi)^{1/2}\cos\Psi$. Software checks are provided to guard against negative frequency solution where $\theta_{Li} < \Psi$; i.e., θ_{Li} is always set $\geq \Psi$. Then each Doppler angle is given by $\theta_{Di} = \mathrm{TAN}^{-1}(X_i{}^2/(H^2+Y_i{}^2))^{1/2}$.

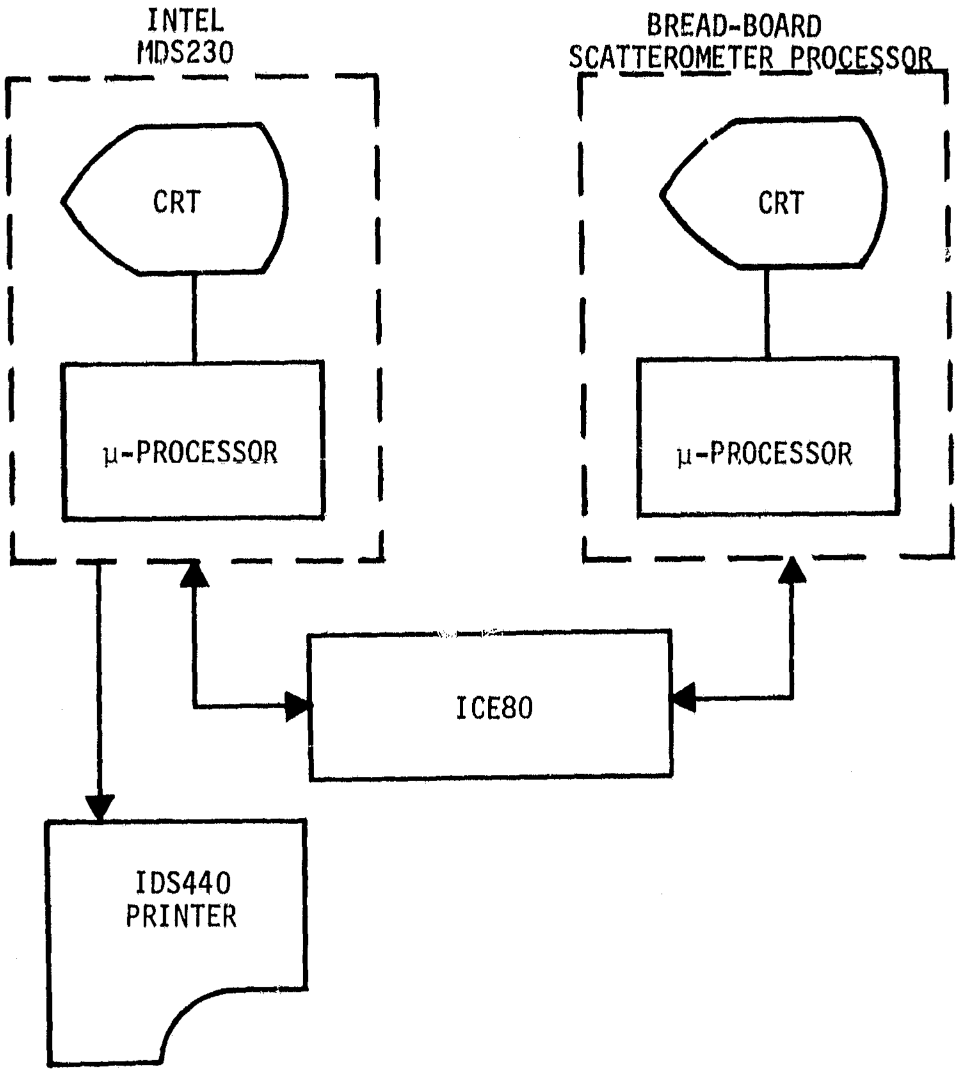


FIGURE 6.4 Module Test Set-Up.

The desired bandwidth is calculated using the expression

$$B_i = (2VL_i\cos^3\theta_{Di})/\lambda H \tag{6.10}$$

where V = aircraft velocity (ground speed)
L_i = cell length (along ground track vector)
θ_{Di} = doppler angle to cell center
λ = wavelength, and
H = altitude of aircraft.

Actual bandwidth is then

$$BW_i = \Delta f[B_i/\Delta f + 0.5]_I \tag{6.11}$$

where Δf is the spectral line width of the filters and the nearest integer value is represented by $[B_i/\Delta f + 0.5]_I$.

Finally, actual bandwidth is used to evaluate upper and lower pointers used to derive power from the filter bank.

6.2.3.2 Calculating σ^0

After all $\sigma^{0'}$ values have been evaluated and after the CZT integration has been completed, the calculation of the power ratio values, P_{Ri}/P_T may be calculated to complete the solution for each σo. This is done in the SIGMA2 module for each of the eight viewing angles.

First, the results of the CZT band integration are transferred to the memory as 512 integers, 32-bits each. Using the pointers derived in the SIGMA1 module, power ratio values, P_{Ri}/P_T, are calculated for each viewing angle by summing appropriate sets of the 32-bit integers. Next, each σ_{0i} is calculated using the expression in

Equation (6.2). Finally, the inner execution loop is completed by buffering all the output data quantities and writing the appropriate buffer line to the Bi-Phase-L output port.

The output data frame produced on the Bi-Phase-L output port for each pass through the processing loop is shown in Appendix C. The first 54 bytes (108 4-bit BCD characters) are copies of the aircraft NERDAS data as received by the system. These 108 characters contain all the time, altitude, location and mission data. Characters 109-172 contain the processed viewing angles and scattering coefficients for each of the eight aft angles. Characters 173-176 and 177-180 contain the calibration and noise power respectively. Flag bits and alarm words are grouped into the characters 181-187. Characters 188-256 are fill data, each containing a hexidecimal 'D', binary 12.

6.2.3.3 'RUN' Termination

The inner-most execution loop is terminated only by 1) reset of the micro-processor, 2) completing the specified number of seconds of data, or 3) operator input of the 'ESC' character on the keyboard. The first type of termination is a hardware reset and provides no logical data set close-out functions. The latter two terminations both cause an orderly close-out of the output buffer and the data file being transferred to the Bi-Phase-L output port.

6.2.4 Testing and Evaluation

Testing was performed in two stages. First, as each executable module or subroutine was completed, independent verification was performed. In general, this was accomplished by preparing special purpose "drivers" which supplied the parameter and/or buffer requirements of the module being tested. This stage constituted the bulk of the project schedule. Secondly, an "all-up" systems test was performed using all modules and sub-routines. This second stage took approximately 1/6th of the total schedule.

Module testing was initially accomplished using the hardware set-up illustrated in Figure 6.4. The ICE80 (in-circuit emulator) and its associated software package in the INTEL MDS230 allowed the software being evaluated to be run at almost real-time while residing in RAM space provided as part of the engineering breadboard system hardware, or within RAM space in the MDS230. Both modes were used, where the selection depended on the particular module being tested.

Over-all system testing was accomplished using the set-up illustrated in Figure 6.5. Aircraft and radar data inputs were provided by the Bi-Phase-L input from the 14-Track AMPEX Tape Unit. Bi-Phase-L output was captured by the TI980, partially decoded and recorded on the 9-track TI979A Tape Unit. Final decoding of the Bi-Phase-L output data was done as a post-run task and the results printed on the printer for analysis. During early May 1980, several demonstration runs were made using the system shown in Figure 6.5. These runs all demonstrated the capability of the system to process C-Band data at a rate of one data frame per 1.5 seconds. The output data quality was compared to data generated by NASA for the same input data set. The results of the over-all system tests showed that the micro-processor based system can produce comparable data (±2.0db) to that produced by much larger and more expensive systems.

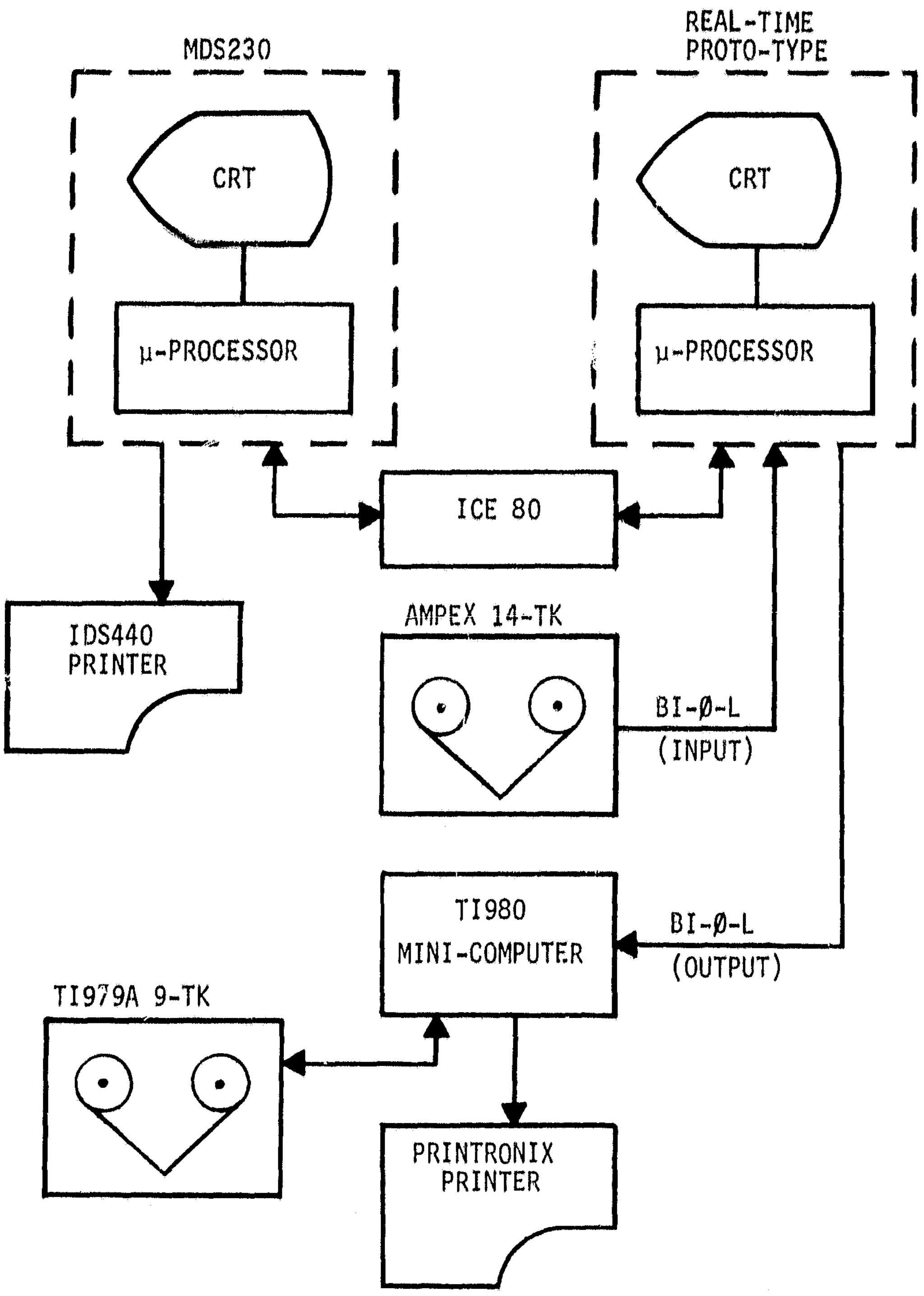


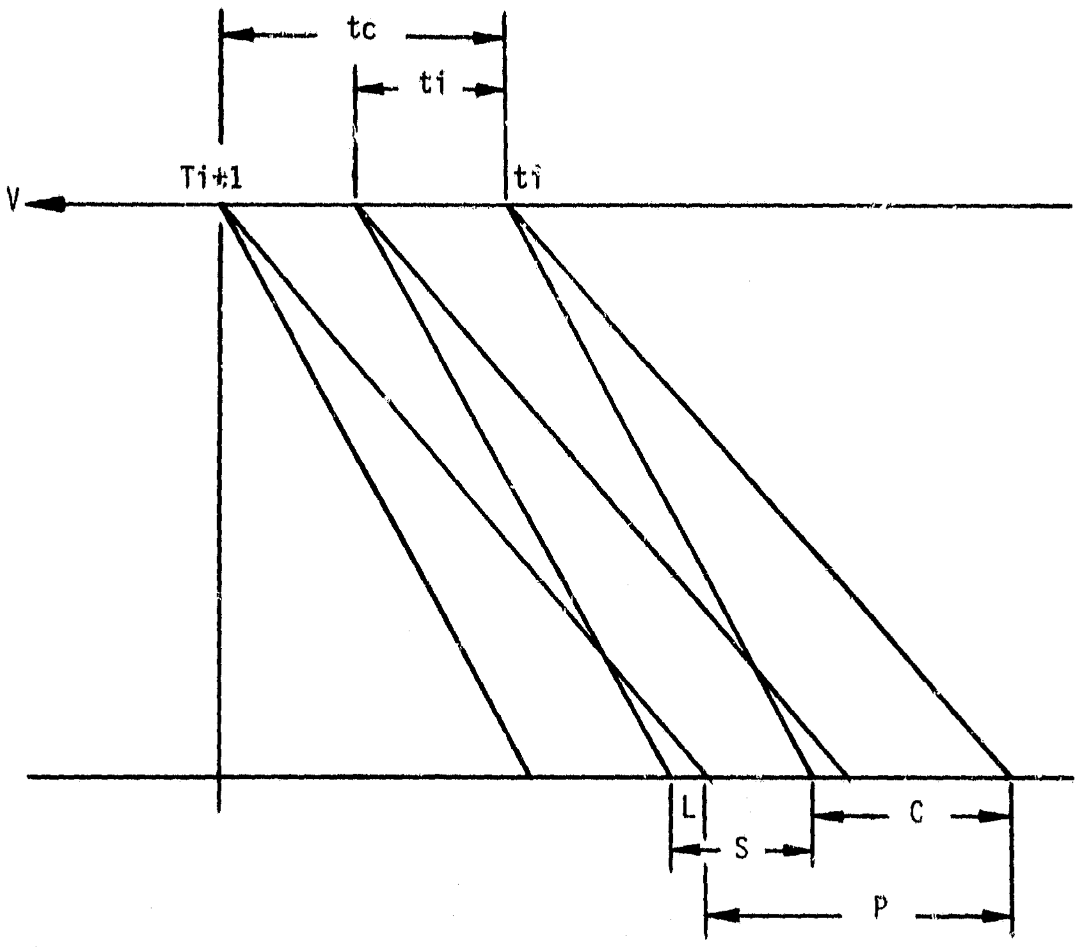
FIGURE 6.5 System Test Set-Up.

Subsequent to the above tests, two tests were run to find out approximately how much time was required to execute each major portion of the software. First, the software inner loop was modified to delete area, range, roll-off, and gain calculations. Those deletions reduced cycle time from approximately 1.5 seconds to 1.05 seconds. Next, the loop was further modified to delete the power-ratio evaluations. This change further reduced the execution loop time to approximately 0.55 seconds. The effect of varying the cycle time, t_c, is only on the effective repetition rate of the viewing cells occurring within the field of view of the radar. This repetition rate also varies with viewing angle, producing greater overlap between successive cells for greater viewing angles. Figure 6.6 shows the geometry of the effect. Using the following expression for cell overlap,

$$L = C + vt_i - vt_c \qquad (6.12)$$

where t_i = integration time
t_c = cycle time
v = velocity of the aircraft,

the parameter plot in Figure 6.7 can be calculated. Note that a cycle time of very near 0.5 seconds is required to always have positive overlap. Negative overlap is produced when the successive ground cells for a given viewing angle are spaced apart. From the parameter plot it can also be shown that for a cycle time of 0.75 seconds cell overlaps will all be greater than -50%, giving a ground coverage of more than 66%. The above timing tests indicate tht if closer cell spacing is required, the present system could be used to produce partially reduced scattering coefficients; i.e., read NERDAS, calculate



L = overlap between successive ground cells
$S + C$ = effective ground cell length
C = instantaneous cell size
$S = Vt_I$, smear length
$P = Vt_C$, cycle length; i.e., start of integration for cell i to start of integration for cell i+1

FIGURE 6.6 Cell Overlap Geometry.

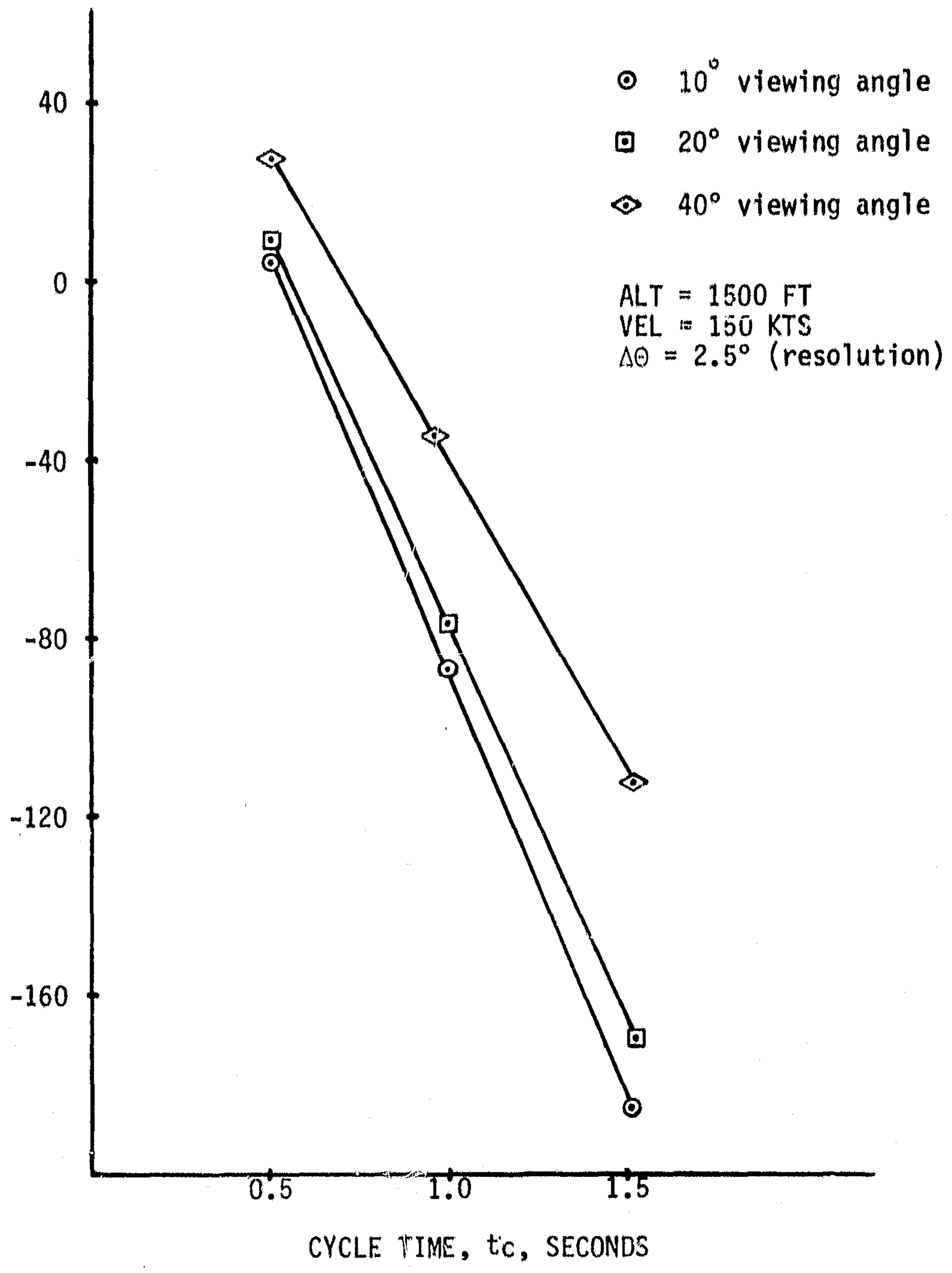


FIGURE 6.7 Cell Overlap vs Cycle-Time

integration times, set and integrate using the CZT board, recover the frequency domain data, place the time correlated power spectral density data on the output port. Also, such a system could operate with a cycle time of approximately 0.6 to 0.7 seconds of which approximately 0.3 seconds is integration time. A small amount of post processing would then be required to yield complete sigma-zero estimates for each ground cell.

Another and perhaps more flexible, alternative to faster processing (full or partial) would be to use fewer viewing angles, say 10, 20, 30, and 45 degrees, or a set selectable by the operator. Approximately half the overhead and buffering tasks would be saved. Such a system could likely run at very near 1.0 second cycle time while producing fully reduced sigma-zero data. Using selectable angles and multiple passes, analysis to any depth desired could be made.

6.2.5 Memory Requirements

As illustrated in Figure 6.8, a large amount of ROM (A000H) will be required to store the data tables and code. A large portion of this space (4000H) is required for inter-communications formatting; i.e., the I/O formatting of communications between the operator and the system. Figure 6.5 also shows the suggested board arrangement to accomplish the appropriate program alignment within the ROM/RAM structure.

6.3 Interrupt Structure

The inner-loop (SIGMA1, SIGMA2) execution uses four interrupt lines. The associated software interrupt jump table is located at

0000	Restart and Interrupt jump table	4K ROM SBC 80/20-4
		4K ROM
0120		SBC 116
		16K ROM
0200		SBC 416, #1
	Code and Data	
		16K ROM
71AA		
		SBC 416, #2
9FFF		
A000		4K Unused
B000		4K RAM SBC 80/20-4
	Variables	
C000		
	and	16K RAM
D000		
	Stack	SBC 116
E000		
	Space	
F000		

FIGURE 6.8 Program Alignment within ROM and RAM.

4000H. The table is loaded under the module name LDJMPS. A level 0 interrupt is generated when the CZT-board completes a timed integration. The subroutine CZTINT handles these interrupts. It causes a flag, IEOC, to be set in the main program, Figure 6.9. The main program, after completing its SIGMA1 tasks, is held in a wait-loop until the IEOC flag is set. After the flag is set, control passes from the SIGMA1 module to the SIGMA2 module where power ratios are calculated using data from the CZT board.

Level 1 interrupts are used for Bi-Phase-L output. A level 1 interrupt signals acknowledge/receipt by the 8255 of the outgoing byte.

Level 3 and Level 4 interrupts are used in NERDAS data inputs. The level 3 interrupt signals a byte is pending. The level 4 interrupt signals that the byte is on the data base.

6.4 Sub-routine Definitions

Most of the inner-loop operations, SIGMA1 and SIGMA2 modules, are accomplished using the subroutine calls defined below.

AFIX(X,I): converts floating point number, X, to integer and places result in I.

AFLOAT(IN,FP): converts integer value, IN, to floating point format and place result in FP.

AINDIX(IN,I80,TEN,AGL,RAD): calculates an index value, IX, using the expression:

IX = IFIX(AGL*RAD-TEN) + I80

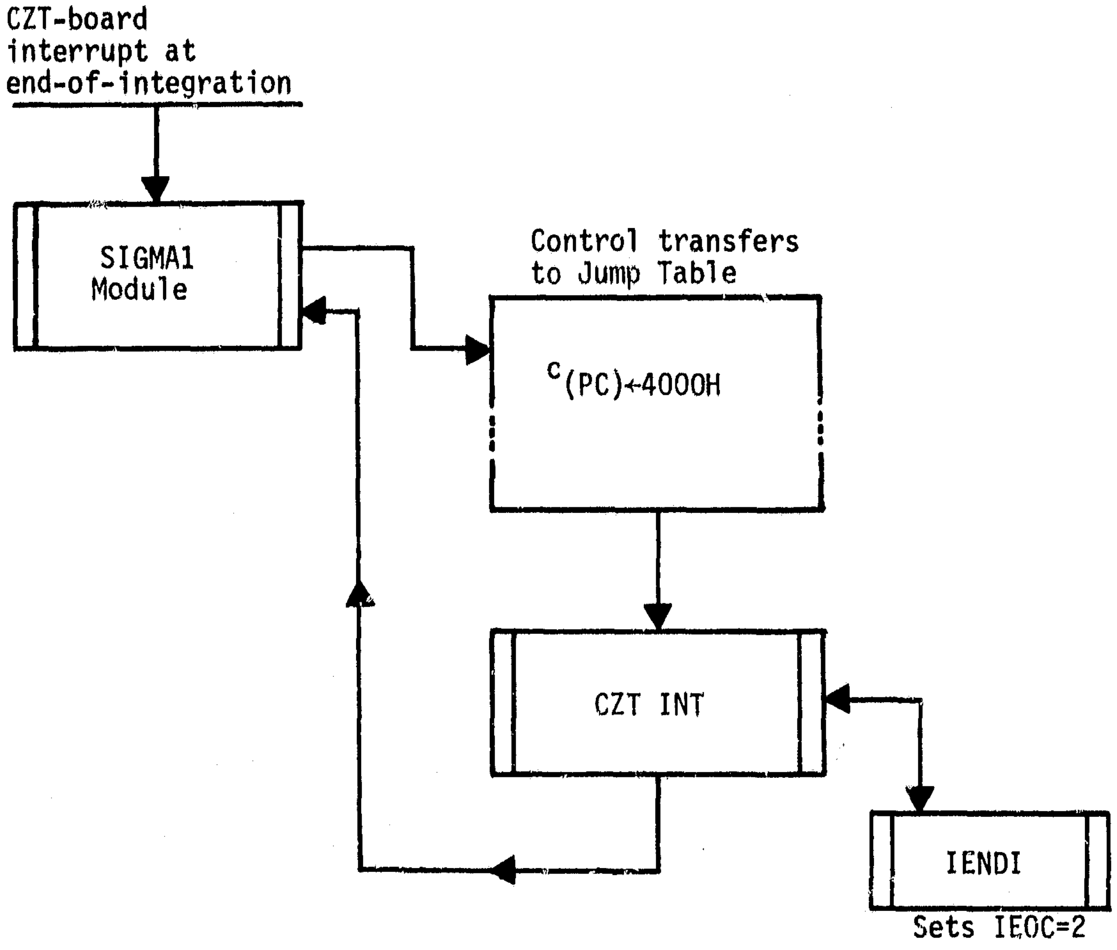

CZT-board interrupt at end-of-integration
SIGMA1 Module
Control transfers to Jump Table
$^{c}(PC) \leftarrow 4000H$
CZT INT
IENDI
Sets IEOC=2

FIGURE 6.9 CZT Interrupt Structure.

where AGL = angle in radians
RAD = constant, 57.3
TEN = constant, 10.0
I80 = constant, 80

Index value is used as a pointer into the L-Band antenna table.

ALTFP(ALT, CALT, ITN, IHD, ITH, IUN): evaluates altitude of the aircraft in meters, using the following expression

ALT = FLOAT(IUN + 10*(ITN + 10*(IHD + 10*ITH)))*CALT

where IUN = NERDAS UNITS digit
ITN = NERDAS TENS digit
IHD = NERDAS HUNDREDS digit
ITH = NERDAS THOUSANDS digit
CALT = constant, 0.3048

Routine is called by DECODA module when decoding NERDAS data.

AMDADD(R,A1,A2): evaluates the result of addition of two floating point numbers, places result in R:

R = A1 + A2

AMDIV(R,A1,A2): evaluates the result of dividing two floating point numbers:

R = A1/A2

AMDGN(DGN,TWO,DG,TEN,I1,I2): calculates interpolation value DGN according to the expression:

DGN = (FLOAT(I1 - I2)/TEN)*DG/TWO

where I1 = upper table index
I2 = lower table index
TEN = 10.0, constant
DG = ABS(AGL*57.3) - FLOAT(IFIX((AGL*57.3 + 0.5)/2.))*2
where AGL = viewing angle through the antenna
TWO = 2.0, constant

AMDGSQ(GSQ,DGN,IGT,TEN): evaluates final gain value by adding iterpolation value DGN to table value using the expression:

GSQ = FLOAT(IGT)/TEN + DGN

where IGT = table value of gain
TEN = constant, 10
DGN = interpolation adjustment

AMDMUL(R,A1,A2): computes product of floating point numbers A1 and A2 according to the expression:

R = A1*A2

AMDSUB(R,A1,A2): evalutes difference of two floating point numbers:

R = A1 - A2

CBNDW(BNDW,NFEL,DELF): calculates actual filter bandwidth according to the expression:

BNDW = FLOAT(NFEL,DELF)*DELF

where NFEL = number of filter elements in the band
DELF = spectral line width of the filter

CCELL(CELL,DIFF,SUM,ALT): evaluates ground cell length according to the expression:

CELL = ALT*(TAN(SUM) - TAN(DIFF))

where ALT = aircraft altitude, meters
SUM = viewing angle plus one-half the resolution angle
DIFF = viewing angle minus one-half the resolution angle

CELCNT(ICNT,VEL,TC,ALT,THET8): computes the number of cells in view (required buffer size) for a given altitude and viewing angle range·

ICNT = IFIX(ALT*TAN(THET8))/(VEL*TC) + 0.5

where ALT = aircraft altitude, meters
VEL = velocity of aircraft (ground speed), meters/sec
TC = processor cycle time, seconds

CINDX(IX,I1,TWO,HALF,D): calculates the index value IX using the the expression:

IX = IFIX((D + 0.5)/TWO) + I1

where D = ABS(AGL*57.3)
AGL = viewing angle through antenna
TWO = constant, 2
I1 = constant, 1
HALF = constant, 0.5

Routine is called by GAIN when evaluating C-Band antenna gain.

CLNPT(IBPT,LT,PC,PN,XT,YI,ANGTD,ALT): calculates buffer loading pointers for viewing angle according to the procedure:

```
ANGTD = ASIN(ANGTD)
   XT = (ALT*ALT + YI*YI)*TAN(ANGTD)**2
 IBPT = LT - IFIX(PC*(TAN(ANGTD) - PN))
```

where		
	ANGTD	= doppler angle
	XT	= X-AXIS INTERCEPT OF DOPPLER CONTOUR
	IBPT	= number of cells aft of nadir to place the σ_0 for the given viewing angle
	LT	= current nadir position in buffer
	YI	= viewing point y-coordinate
	PC	= (ALT/VEL)/TC
	PN	= (TI/PC)*0.5
	TI	= integration time

CNFILT(NFEL,DEL,BNDW,CELL,FDOP,ANGLD,YI,XI,XT,S): calculates number of filter elements required to represent each viewing angle band. Routine implements the following:

```
   XT = (2.*VEL)/SLMDA
ANGLD = ATAN(SQRT((XI*XI)/(ALT*ALT + YI*YI*)))
 FDOP = XI*SIN(ANGLD)
 BNDW = (CELL*XT/ALT)*COS(ANGLD)***3
 NFEL = IFIX(BNDW/DEL + 0.5)
```

where		
	SLMD	= wavelength
	ANGLD	= doppler angle
	XI,YI	= viewing point coordinates
	FDOP	= doppler center frequency

CRG4(RG4,FRTY,ALT,ANGTL): evaluates the range of the cell center from the antenna. Value, RG4, is returned in db according to the expression:

```
RG4 = 40.*ALOG10(ALT/COS(ANGTL))
```

where		
	FRTY	= constant, 40.0
	ALT	= altitude, meters
	ANGTL	= viewing angle, radians

CZT(N): set and start integration of N sub-records

CZTR: start DMA transfer of 512 filter elements from the CZT board

DAREA(AL,TEN,TRM1,TRM2,TRM3): computes the area of a ground cell according to the expression:

```
AL = 10.*ALOG10(TRM1*(TRM2 - TRM3))
```

where AL = area in db
TRM1 = width of ground cell
(TRM2 - TRM3) = length of ground cell

DECODA(IOV,NERZ,T1,PARM): Decodes NERDAS frame. Uses subroutines as follows:

ALTFP:	decodes altitude up to 9999. feet
DRPFP:	decodes drift, roll, pitch up to 99.9 degrees
VELFP:	decodes velocity up to 999. knots
MINHR:	decodes minutes, hours
TSECS:	decodes seconds

DRPFP(DRP,CRAD,ISGN,ITN,IHD,IUN): converts NERDAS digits to drift, roll, or pitch in radians:

DRP = FLOAT((IUN + 10*(ITN + 10*IHD))*ISGN)/CRAD

where CRAD = 57.3
IUN = units digit of NERDAS
ITN = TENS digit of NERDAS
IHD = HUNDREDS digit of NERDAS
ISGN = sign digit of NERDAS

DVERIF(ICNT,IBUFF): edits a buffer, IBUFF, containing ICNT bytes for ASCII decimal characters. Any character, other than decimal or leading unary, is converted to a blank.

DWAIT: a linkage routine for FORTRAN error recovery. Assumes control of program counter until a machine reset.

FDLEV(IFDL,NFEL,NEV,FDOP,DELF): evaluates starting pointer for summing spectral power when the number of filter elements in the filter band is even and uses the expression:

IFDL = IFIX(FDOP/DELF) + NEV - NFEL/Z

where FDOP = doppler center frequency
DELF = spectral line width
NEV = constant, 3
NFEL = number of filter elements in the filter

FDLOD(IFDL,NFEL,NOD,FDOP,DELF): evaluates starting pointer for summing spectral power when the umber of filter elements in the filter band is odd. It uses the expression:

IFDL = IFIX(FDOP/DELF + 0.5) + NOD - (NFEL - 1)/2

where NOD = constant, 2.

GAIN(ANG,PCH,IGTBL,IGTBC,NPZN,IBND,GSQ): calculates antenna gain, GSQ, for either L-Band or C-Band using a table look-up and interpolation procedure. Input parameters are:

ANG	=	antenna view angle in radians
PCH	=	aircraft pitch, in radians
IGTBL	=	L-Band gain table
IGTBC	=	C-Band gain table
NPZN	=	polarization identifier, W=1, VH=2, HH=3, HV=4
IBND	=	band identifier, L=1, C=2

GAML(Z,C1,C4,C5,CZ,F,C3): evaluates the value of Z, roll-off, in db for L-Band using the expression:

```
Z = -(C1 + F*(CZ + C3*F) + (C4 + C5/F)/F)
```

where F = frequency/10.
C1, ..., C5 = constants

GAMC(Z,C1,CZ,C3,C4,C5,C6,C7,F): evaluates the value of Z, roll-off, in db for C-Band using the expression:

```
Z = C1 + F*(CZ + F*(C3 + F*(C4 + C5*F))) + (C6 + C7/F)/F
```

where F = frequency/10.
C1, ..., C7 = constants

GAMMA(FRQ,IB,NPZ,Z): evaluates roll-off, Z, using subroutine calls to GAML or GAMC depending on band identifier, IB. Computes F = FRQ/10. before calling subroutine. NPZ is the polarization identifier.

GETVLU(CIOBUF,IOBUFF,N10,N20,IERR,XNUM): acquires from console the floating point number, XNUM. CIOBUF and IOBUFF are the input buffers, N10 = constant, 10, and N20 = constant, 20.

GXI(XI,XT,ALT,RL,DR): computes X-coordinate, XI, using the expression:

```
IX = XT*COS(DR) + ALT*TAN(RL)*SIN(DR)
```

where XT = SQRT(ALT*TAN(ANGL))**Z - (ALT*TAN(RL)**Z), calculated in subroutine GXT, below.
DR = drift in radians
ALT = altitude, meters
RL = roll

GXT(XT,RL,ANGL,ALT): evaluates XT, used in the above subroutine, using the expression:

XT = SQRT(ALT*TAN(ANGL))**2 - (ALT*TAN(RL))**)

where ANGL = viewing angle.

GYI(YI,XT,ALT,RL,DR): calculates the Y-coordinate of the viewing point, YI, using the expression:

YI = XT*SIN(DR) - ALT*TAN(RL)*COS(DR)

where XT is as calculated by the subroutine GXT above.

IBELL: sends bell character to CRT. No calling parameters.

IBFILL(L,IBUFF): fills 128 byte buffer lines with 99H, L = line count and IBUFF = buffer starting address.

IBIPHL(IBUFF): move 128 bytes beginning at IBUFF to the 8255 serial port.

ICRLF: routine to output a carriage return and line-feed to the CRT.

IKEYI: sets flag for keyboard 'ESC' input. Called by KEYCK.

INIPIO: initializes parallel I/O port on the SBC 80/20 board.

INICZT(IPSD): initializes CZT board with DMA address, IPSD.

INI259: initializes the 8259 interrupt controller for the vested mode at 4 byte intervals. Call table set at 4000H. Leaves interrupts enabled but all masked.

INTGT(ICNT,TI,DELF): calculates the number of subrecords over which to integrate. Uses expression:

ICNT = IFTX(TI*DELF + 0.5)

where TI = integration time, seconds
DELF = spectral line width of CZT

IUSART: initializes the USART for CRT/keyboard I/O.

I32SUM(PX,NV,IV): calculates the sum of a set of 'IV' 32-bit integers beginning at NV(1), and extending to NV(IV). The result in db is placed in PX, and uses the expression:

PX = 10.*ALOG10(FLOAT(NV(1) + NV(2) + ... + NV(IV))

KBPHAL(IOUT): control routine for handing Bi-Phase-L output. Sends out a 128 byte line from IOUT then backfills the line with 99H. Calls IBIPHL to write the line to the serial interface.

KEYCHK: senses the keyboard for an escape character. If no character is pending or if character is not an 'ESC', no action is taken. If 'ESC' is found, a branch is taken to subroutine IKEYI to set a main program flag, KESC.

KEYIN(N,IB): key board input routine. Reads keyboard to place N characters in IB, left justified. As each character is read, it is echoed to the CRT; 'ESC' is echoed as a '$'.

MSKSET(MSK): sets 8259 interrupt mask to the value MSK.

MINHR(IMH,NU,NT): evaluates minutes or hours from NERDAS digits using the expression:

$$IMH = NT*10 + NU$$

where NT = tens digit
NU = units digit

MFLAG(IC,IOF,IOUT,IB,NZ): moves flag data words to output buffer line.

IC = column count in buffer
IOF = flag word buffer
IOUT = output buffer
IB = band identifier
NZ = polarization identifier

Seven flag words are placed in the output line then the line is finished by filling it with DDH.

MFPNUM(FPNBR,ICOL,IBPT,IOUT,IBCD,NK): moves up to 8 floating point numbers into the output buffer after they have been converted to BCD (binary coded decimal). NK = number values to convert and move. FPNBR = buffer of floating point numbers. The numbers, starting at FPNBR, are converted one at a time into a BCD buffer IBCD, then moved to a location in the output buffer. ICOL and IB are pointers into the output buffer, IOUT.

NERD(ICNT) reads Bi-Phase-L for ICNT bytes of NERDAS data.

OUTPUT(N,IBUFF): outputs a character string of N bytes beginning at IBUFF. String is sent to CRT or logging device at port CCH.

PCPN(PNTI,PC,TC,ALT,VEL): calculates the parameters PC and PN used in evaluating the required buffer length. Implements:

PC = (ALT/VEL)/PC
PN = (TI/(ALT/VEL)*0.5

RUNLMT(PREV,IOVER,PARM): checks aircraft data (altitude, drift, roll, pitch, velocity) to verify that it is within prescribed limits. The prescribed limits are set by monitoring a limited number of previous values. The previous values have also been monitored against a preset standard.

SIGSUM(SGMA,ZW,AL,GSQ,SYSK,RG4,FP): computes the final value of σ_0. Uses the expression:

SGMA = FP + RG4 + SYSK - GSQ - AL - ZW

where all parameters are in db.

FP	=	$(4\pi)^3/\lambda^2$
RG4	=	R^4, range parameter
SYSK	=	C_L/K, system constant
GSQ	=	GG($_{Li}$), antenna gain
AL	=	area of ground cell
ZW	=	roll-off function value

TIMEFP(T1,ITS,IM,IH): computes floating point value of time in seconds by:

T1 = FLOAT(IH*60 + IM)*60. + FLOAT(ITS)/10.

where

IH	=	NERDAS hours
IM	=	NERDAS minutes
ITS	=	NERDAS tenths of seconds

TMP12(TMP1,VEL,X12): evaluates the ground cell parameter TMP1 using the expression:

TMP1 = X12*(VEL**2)

where X12 = XK1 or XK2, as defined in Reference (2).

TRM1(T1BMW,ANG,ALT,RL): evaluates the ground cell area term T1 using the expression:

T1 = 2.*TAN(BMW/2.)*(ALT**2)/COS(RL)/COS(ANG)

where

BMW	=	beamwidth
ANG	=	viewing angle
RL	=	roll

TRM23(TRM,TMP1,RL,DR): calculates the ground cell area term TRM according to the expression:

```
TRM = (-TAN(DR)*TAN(RL) + SQRT(TAN(RL)**2*(TMPI - 1.)

            + TMP1*COS(DR)**2 - (1. - TMP1*COS(DR)**2)
```

where TRM = TRM2 or TRM3 of the area equation.

TSECS(ITS,ITN,IHD,IUN): evaluates seconds from NERDAS date by

```
ITS = 10*(ITN + 10*IHD) + IUN
```

where ITN = tens digit
IHD = hundreds digit
IUN = units digit

UNPACK(INN,INB): unpacks a frame of 58 NERDAS NIBS at INN (2 BCD values per byte) into a buffer at INB with 1 BCD value per byte. INB is 55 bytes in length. First 2 NIBS are skipped.

VALID(DL,DF,IOV,IVAL,PARM): validates NERDAS data values unles the override flag is set. If value is outside preset limits, the default value is used. Whenever default values are used an appropriate flag is set in the output buffer. Calling parameters are

DL =	preset limit values (buffer of 10 values)
DF =	preset default values (buffer of 5 values)
IOV =	override flag buffer
IVAL =	flag byte
PARM =	buffer of NERDAS parameters; i.e., alt., pitch, roll, drift, velocity

VELFP(VEL,CVEL,ITN,IHD,IUN): computes velocity of the aircraft in meters per second using the expression

```
VEL = FLOAT(IUN + 10*(ITN + 10*IHD))*CVEL
```

where CVEL = 0.514
IHD = NERDAS hundreds digit
ITN = NERDAS tens digit
IUN = NERDAS units digit

XK12(XK2,XK1,SLMDA,BNDW,FDOP): evaluates the two area terms XK1, XK2, using the expressions:

```
XK1 = 4./(SLMDA*(FDOP - BNDW/2.)**2
XK2 = 4./(SLMDA*(FDOP + BNDW/2.)**2
```

C-2

where	SLMDA = wavelength, meters.
	DFOP = doppler center frequency
	BNDW = filter bandwidth

6.5.0 AMC95/6011 Arithmetic Unit Operations

All inner-loop arithmetic, except indexing, is accomplished using the hardware floating point arithmetic board. These operations are all accomplished using the following set of device calls:

AMDCMD: routine to send a command in the A-register to the AMC 95/6011.

AMDLOD: loads a floating point number at the address in register-pair BC into the AMC 95/6011.

AMDSTR: stores a floating point number in INTEL format from the AMC 95/6011 internal register. Storage address is expected to be in register pair BC.

GET: gets a floating point number in AMC 95/6011 internal register and stores it at the address in register pair DE.

GIVE: gives a floating point number in AMC format located at the address in register pair DE to the AMC 95/6011 internal register.

INTLOD: loads a 16-bit integer at address in register pair BC into the AMC 95/6011 internal register.

INTSTR: stores a 16-bit integer at the address in register pair BC. Integer is retrieved from the AMC 95/6011 internal register.

I32LOD: loads a 32-bit integer at the address in register pair BC into the AMD 95/6511 internal register.

REFERENCES

1. John P. Claassen, et al., "The System and Hardware Design of Real-Time Fan Beam Scatterometer Data Processors," Final ReportRSC3556, Remote Sensing Center, Texas A&M University, College Station, Texas. March 1979.

2. "Definition and Fabrication of an Air borne Scatterometer Radar Signal Processor," Technical Report RSC3182-2, Remote Sensing Center, Texas A&M University, NASA Contract NAS9-14493, December 1976.

3. Reeves, R. G., et al., Manual of Remote Sensing, American Society of Photogrammetry, 1975.

4. Claassen, J. P., "Accuracy Criterion for Estimating the Mean Squared Signal," Rsl-TM 186-1, Remote Sensing Laboratory, University of Kansas, 1970.

5. Oppenheim, A. V. and R. W. Schafer, Digital Signal Processing, Prentice-Hall, Inc., 1975.

6. Claasen, J. P., "The Design of the RADSCAT Experiments," RSL-TR-186-2, Remote Sensing Laboratory, University of Kansas, 1971.

7. B. V. Clark and R. W. Newton, "JSME Scatterometer Data Processing," Texas A&M University, Remote Sensing Center, August 1979.

8. ___________, "An Airborne Radar Scatterometer Signal Processing System," Progress Report, February - April 1975.

9. Advanced Micro Computers, "AMC 95/6011 Arithmetic Processing Unit Board User's Manual," Revision A, 1978.

APPENDIX A

System Flow Charts

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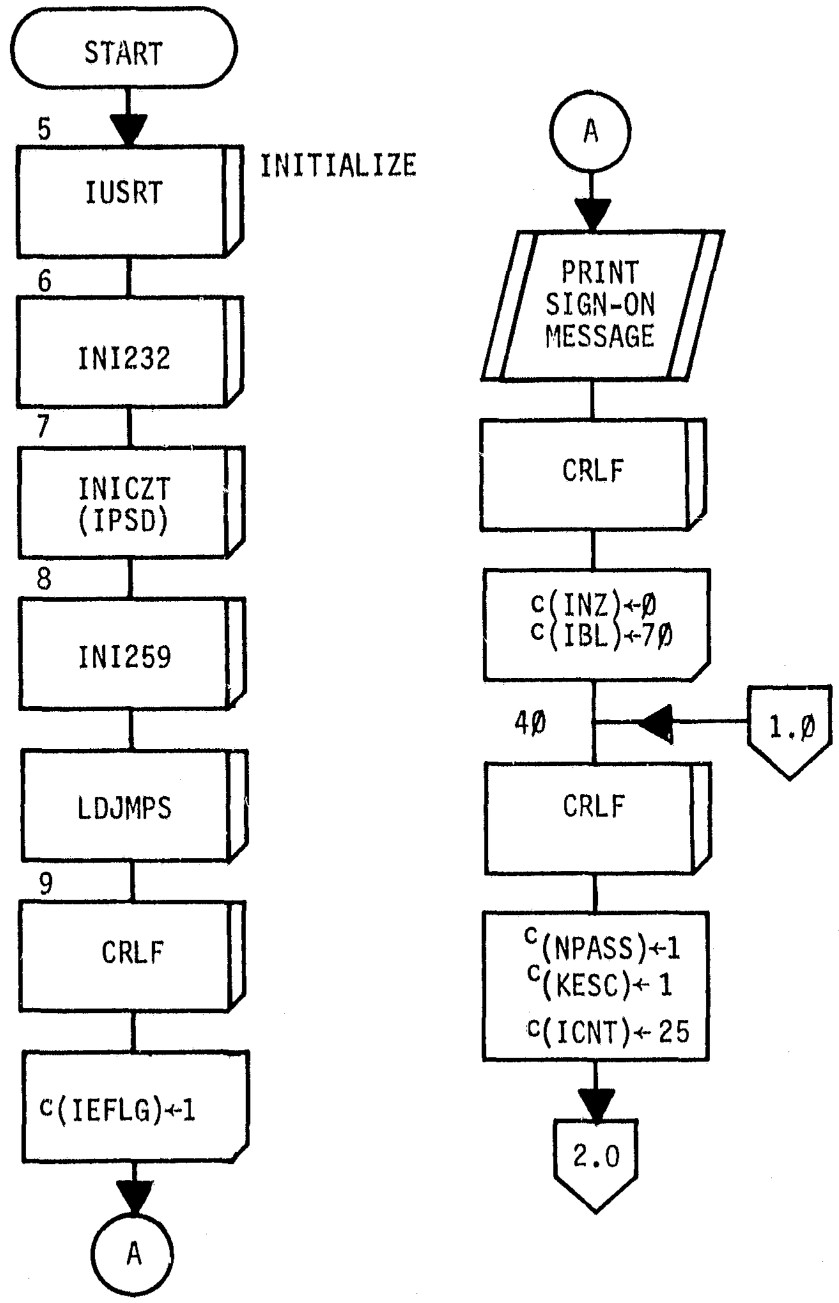
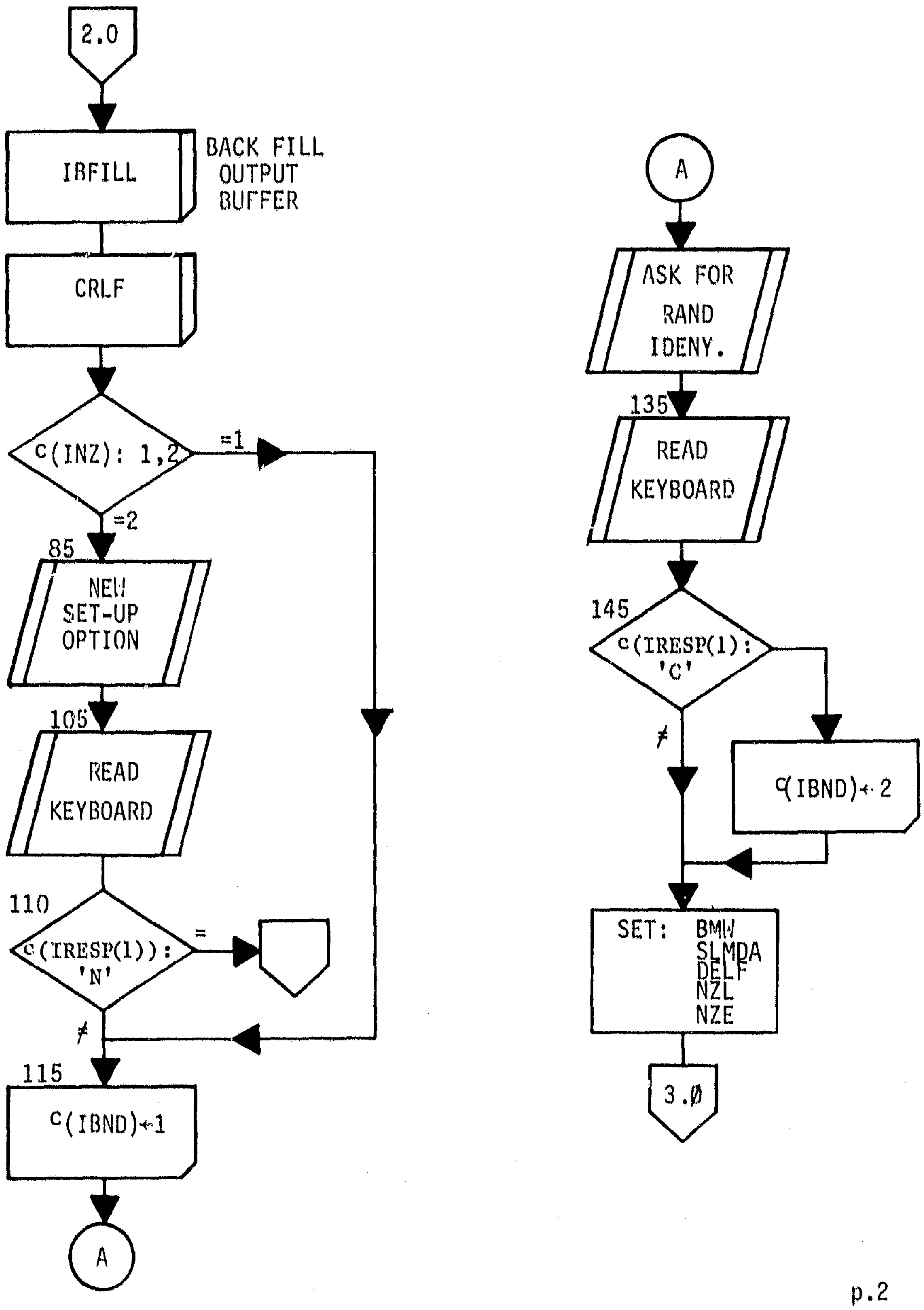
OPERATOR COMMUNICATIONS MODULE

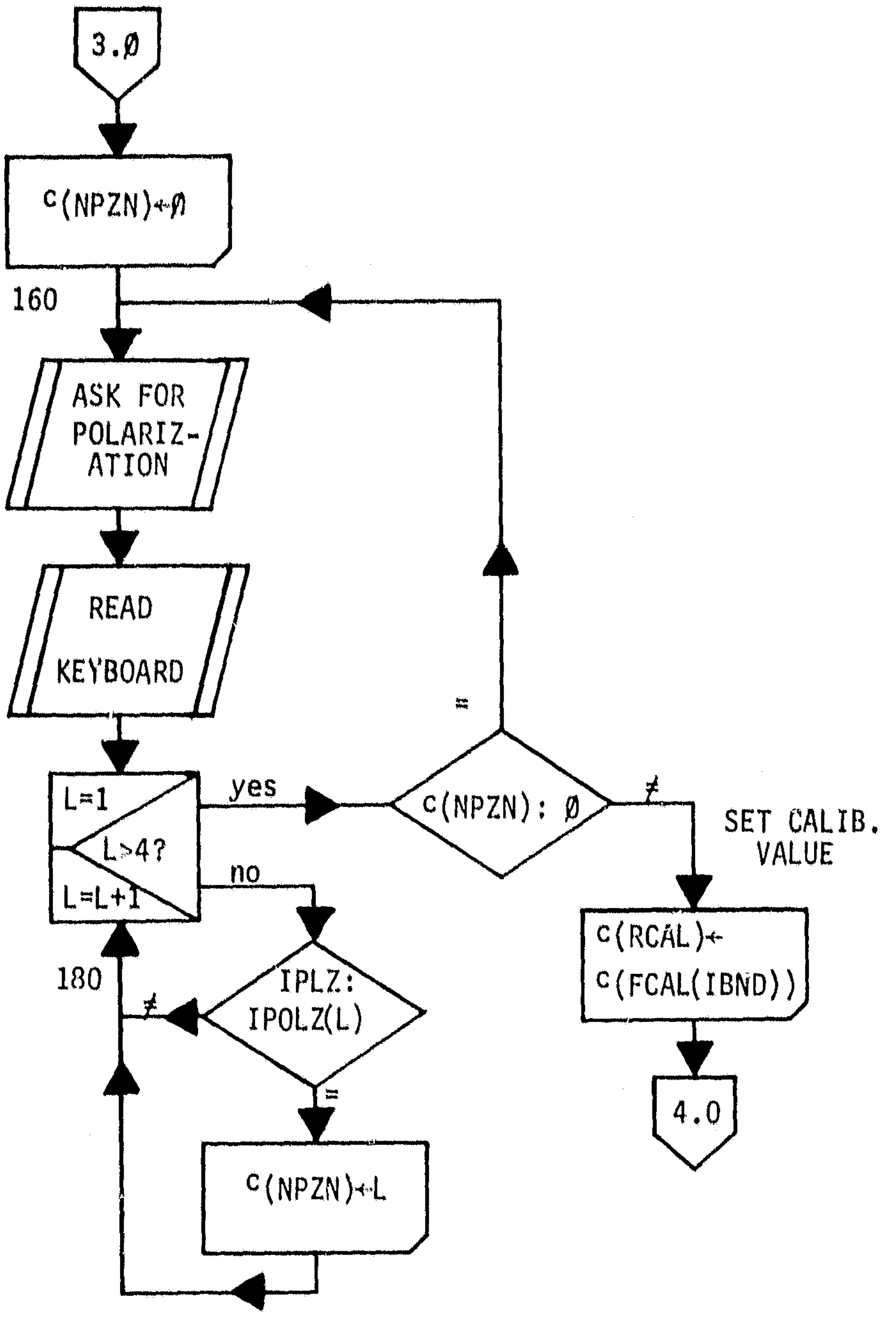


p.1

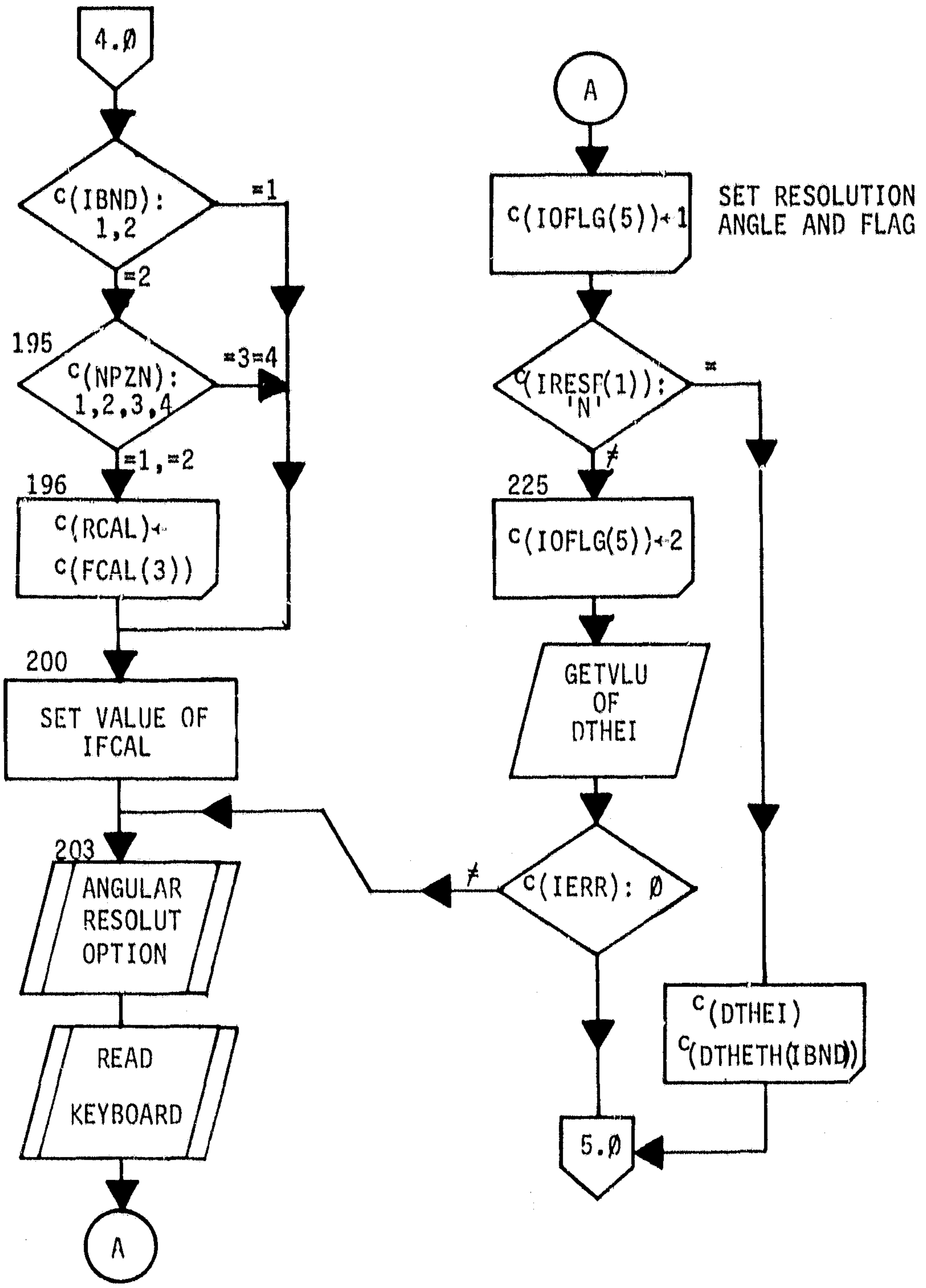
PRECEDING PAGE BLANK NOT FILMED


2.0
IBFILL
BACK FILL OUTPUT BUFFER
CRLF
c(INZ): 1,2
=1
=2
85
NEW SET-UP OPTION
105
READ KEYBOARD
110
c(IRESP(1)): 'N'
=
≠
115
c(IBND)←1
A
A
ASK FOR RAND IDENY.
135
READ KEYBOARD
145
c(IRESP(1): 'C'
≠
c(IBND)←2
SET: BMW SLMDA DELF NZL NZE
3.Ø

p.2

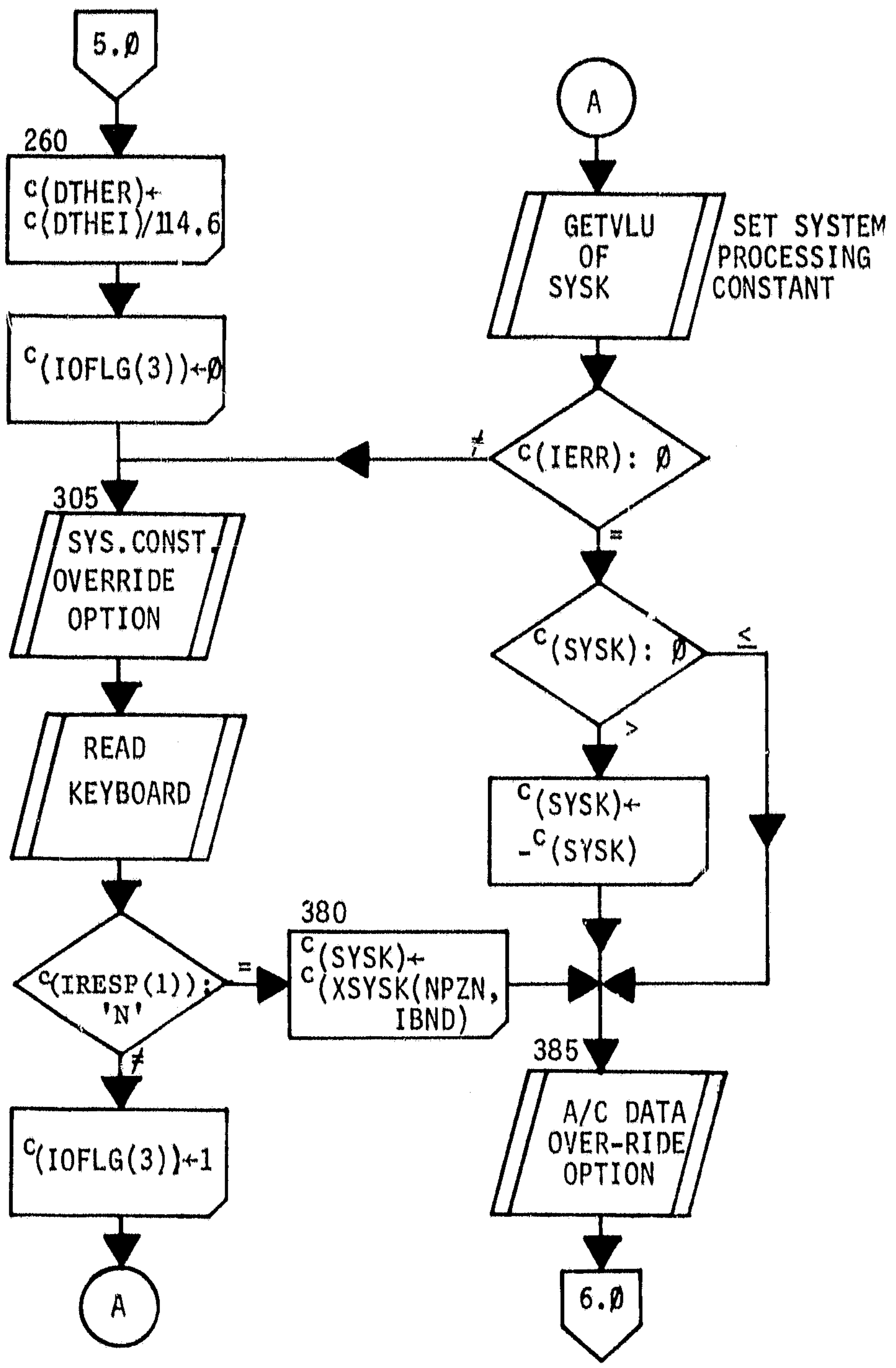

3.Ø
c(NPZN)←Ø
160
ASK FOR POLARIZ-ATION
READ KEYBOARD
L=1
L>4?
L=L+1
yes
no
c(NPZN): Ø
=
≠
SET CALIB. VALUE
c(RCAL)←
c(FCAL(IBND))
4.0
180
IPLZ:
IPOLZ(L)
≠
=
c(NPZN)←L

p.3

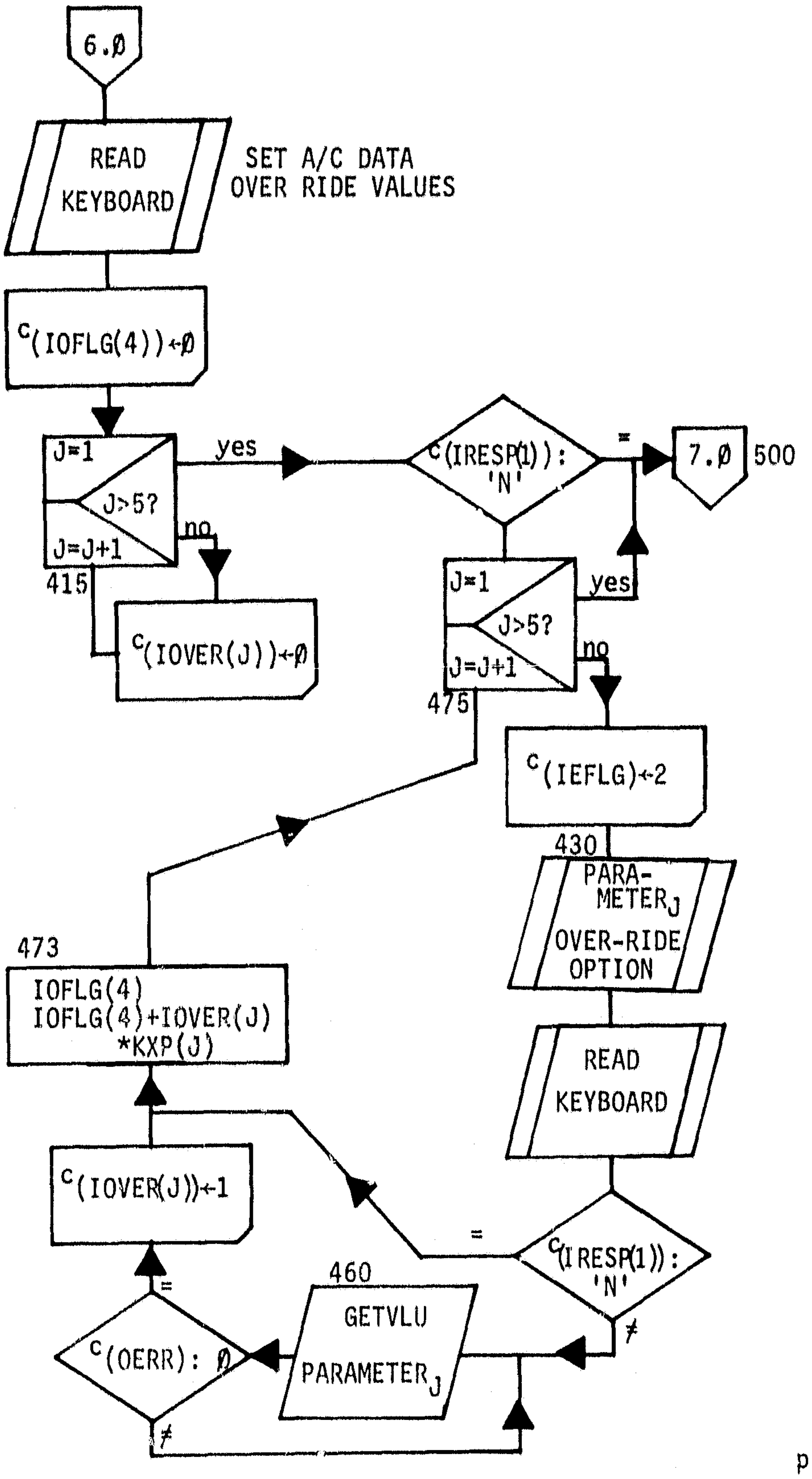


4.Ø
c(IBND): 1,2
=1
=2
195
c(NPZN): 1,2,3,4
=3=4
=1,=2
196
c(RCAL)← c(FCAL(3))
200
SET VALUE OF IFCAL
203
ANGULAR RESOLUT OPTION
READ KEYBOARD
A
A
c(IOFLG(5))←1
SET RESOLUTION ANGLE AND FLAG
c(IRESP(1)): 'N'
=
≠
225
c(IOFLG(5))←2
GETVLU OF DTHEI
c(IERR): Ø
≠
c(DTHEI) c(DTHETH(IBND))
5.Ø

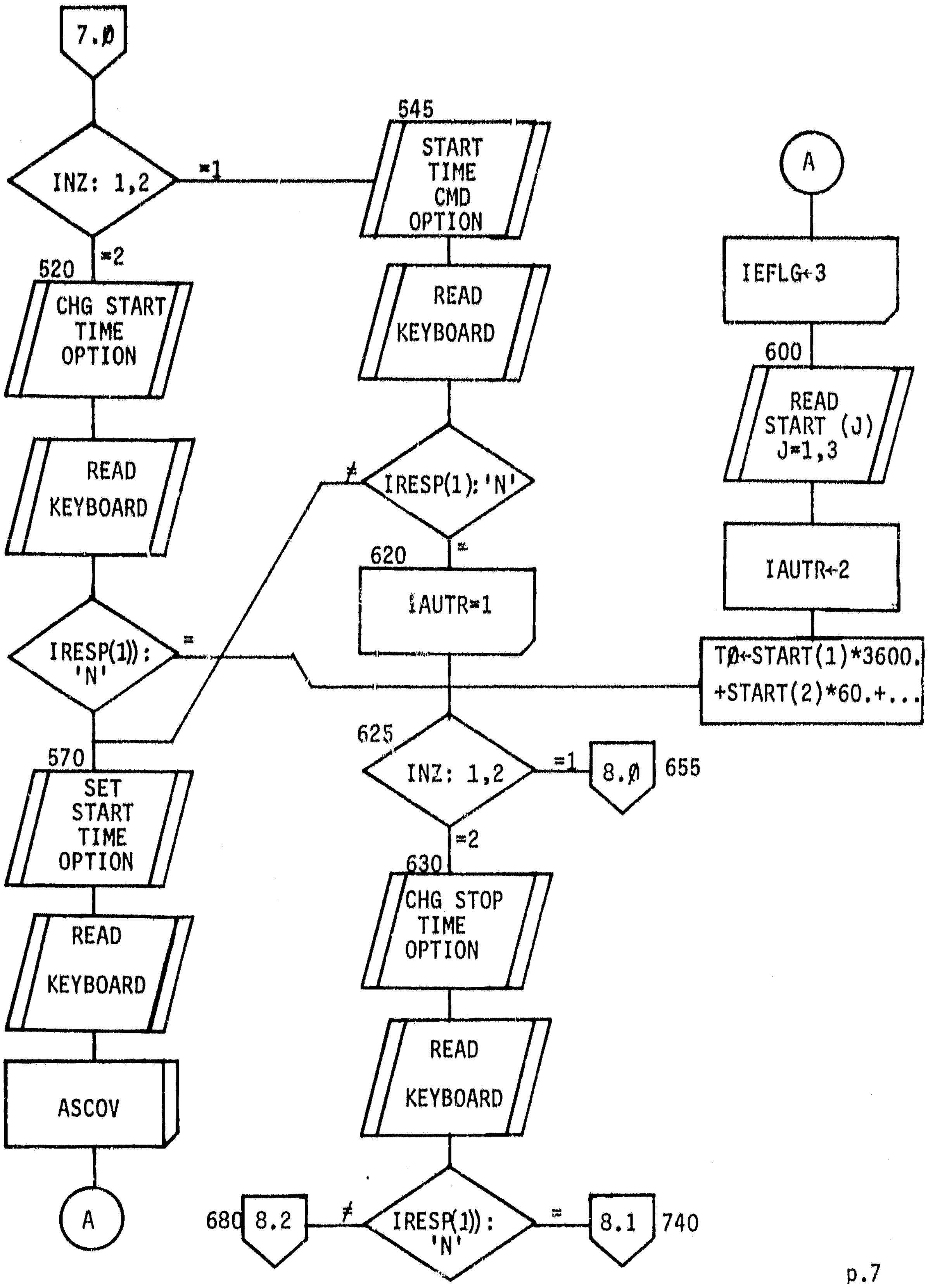
p.4


5.Ø
260
c(DTHER)←
c(DTHEI)/114.6
c(IOFLG(3))←Ø
305
SYS.CONST.
OVERRIDE
OPTION
READ
KEYBOARD
c(IRESP(1)):
'N'
=
≠
c(IOFLG(3))←1
A
380
c(SYSK)←
c(XSYSK(NPZN,
IBND)
A
GETVLU
OF
SYSK
SET SYSTEM
PROCESSING
CONSTANT
c(IERR): Ø
≠
=
c(SYSK): Ø
≤
>
c(SYSK)←
-c(SYSK)
385
A/C DATA
OVER-RIDE
OPTION
6.Ø

p.5

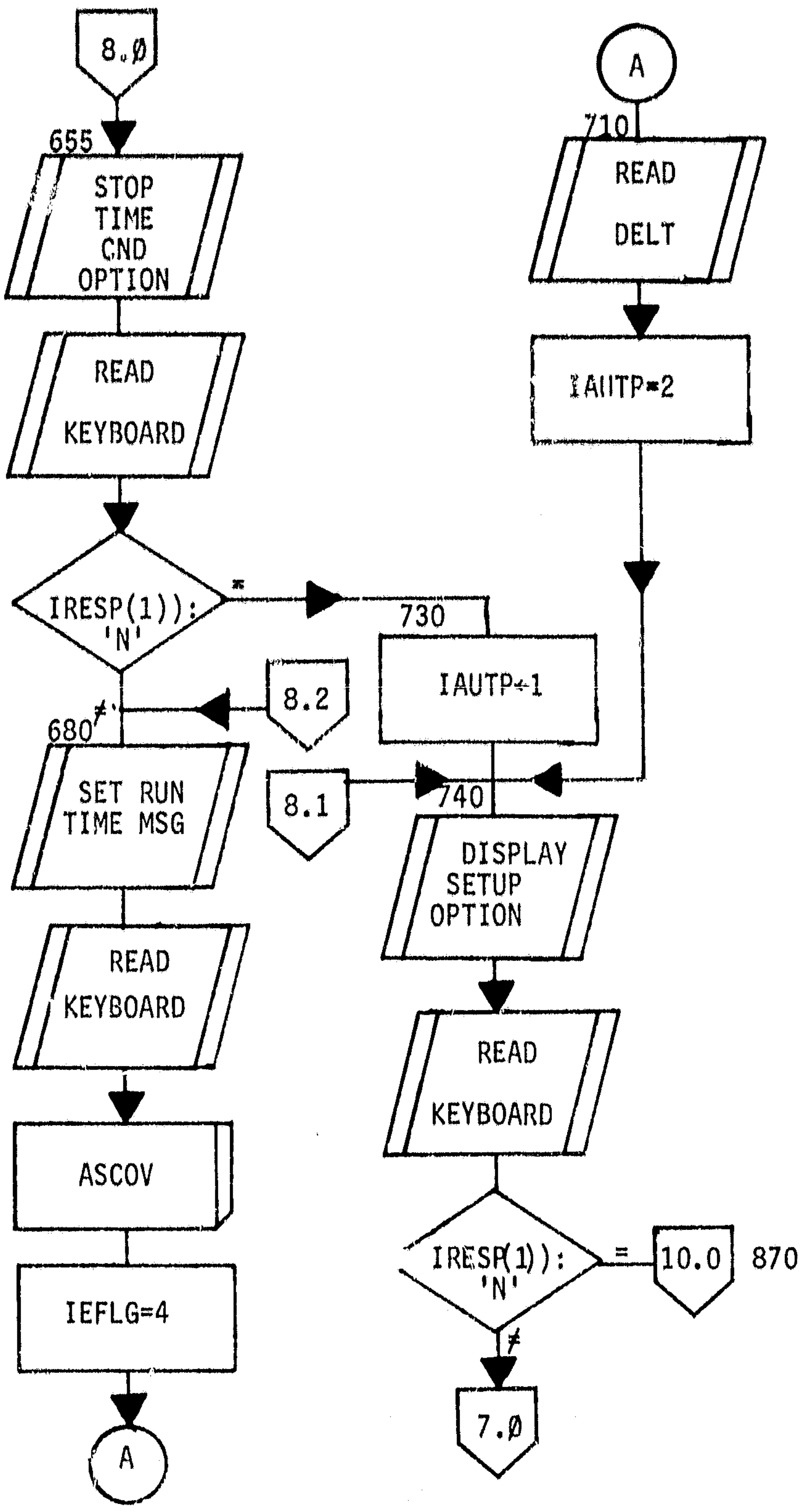

6.∅
READ KEYBOARD
SET A/C DATA OVER RIDE VALUES
c(IOFLG(4))←∅
J=1
J>5?
J=J+1
415
yes
no
c(IOVER(J))←∅
c(IRESP(1)): 'N'
=
7.∅
500
J=1
J>5?
J=J+1
475
yes
no
c(IEFLG)←2
430
PARA-METER$_J$
OVER-RIDE OPTION
READ KEYBOARD
c(IRESP(1)): 'N'
=
≠
473
IOFLG(4) IOFLG(4)+IOVER(J) *KXP(J)
c(IOVER(J))←1
460
GETVLU PARAMETER$_J$
c(OERR): ∅
=
≠

p.6

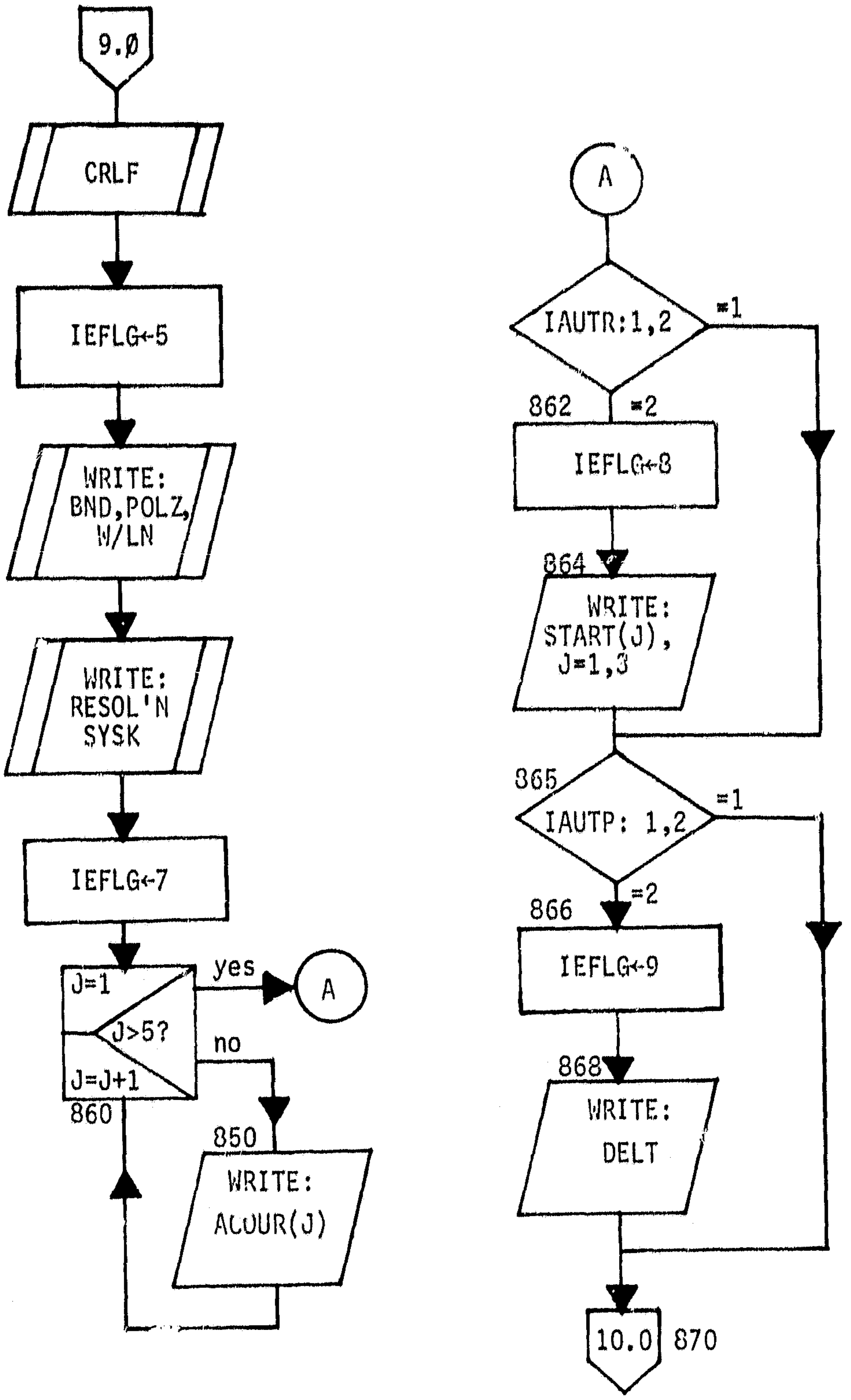


7.∅
INZ: 1,2
=1
=2
545
START TIME CMD OPTION
520
CHG START TIME OPTION
READ KEYBOARD
READ KEYBOARD
IRESP(1): 'N'
≠
=
620
IAUTR=1
IRESP(1): 'N'
=
A
IEFLG←3
600
READ START (J) J=1,3
IAUTR←2
T∅←START(1)*3600. +START(2)*60.+...
625
INZ: 1,2
=1
8.∅
655
=2
570
SET START TIME OPTION
READ KEYBOARD
ASCOV
A
630
CHG STOP TIME OPTION
READ KEYBOARD
680
8.2
≠
IRESP(1): 'N'
=
8.1
740

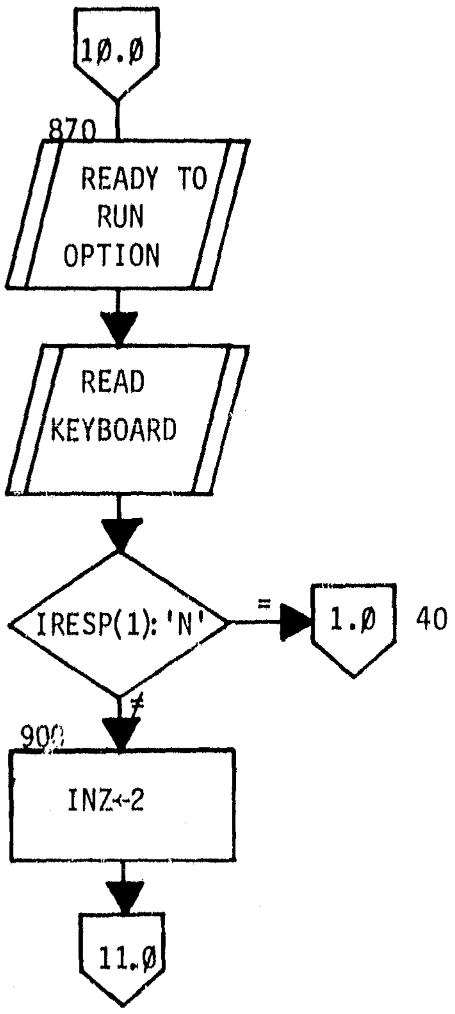
p.7


8.Ø
655
STOP TIME CND OPTION
READ KEYBOARD
IRESP(1)): 'N'
=
730
IAUTP←1
≠
680
8.2
SET RUN TIME MSG
8.1
740
DISPLAY SETUP OPTION
READ KEYBOARD
ASCOV
IEFLG=4
A
A
710
READ DELT
IAUTP=2
IRESP(1)): 'N'
=
10.0
870
≠
7.Ø

p.8


9.Ø
CRLF
IEFLG←5
WRITE: BND,POLZ, W/LN
WRITE: RESOL'N SYSK
IEFLG←7
J=1
J>5?
J=J+1
860
yes
A
no
850
WRITE: ACOUR(J)
A
IAUTR:1,2
=1
862
=2
IEFLG←8
864
WRITE: START(J), J=1,3
865
IAUTP: 1,2
=1
866
=2
IEFLG←9
868
WRITE: DELT
10.0
870

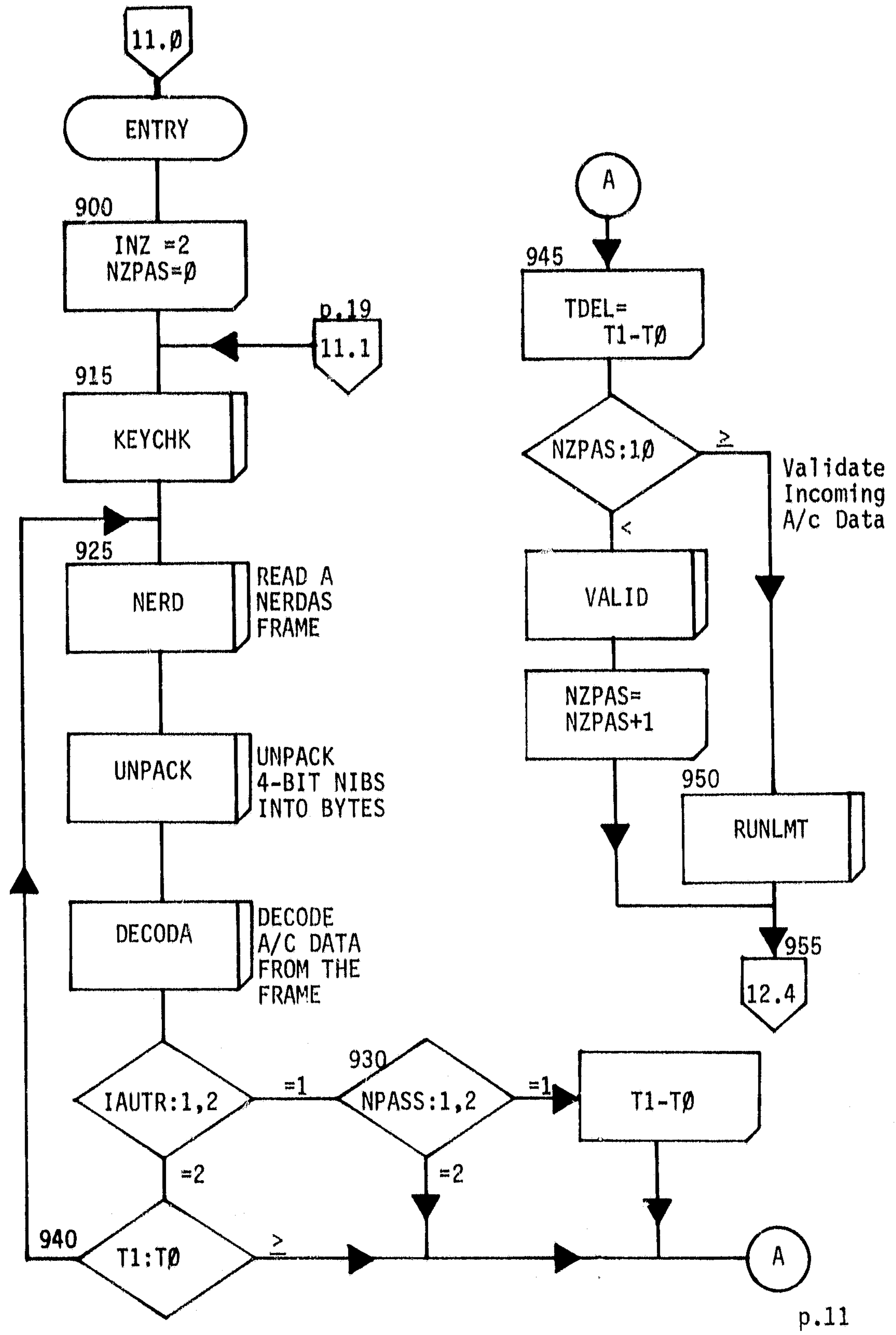
p.9

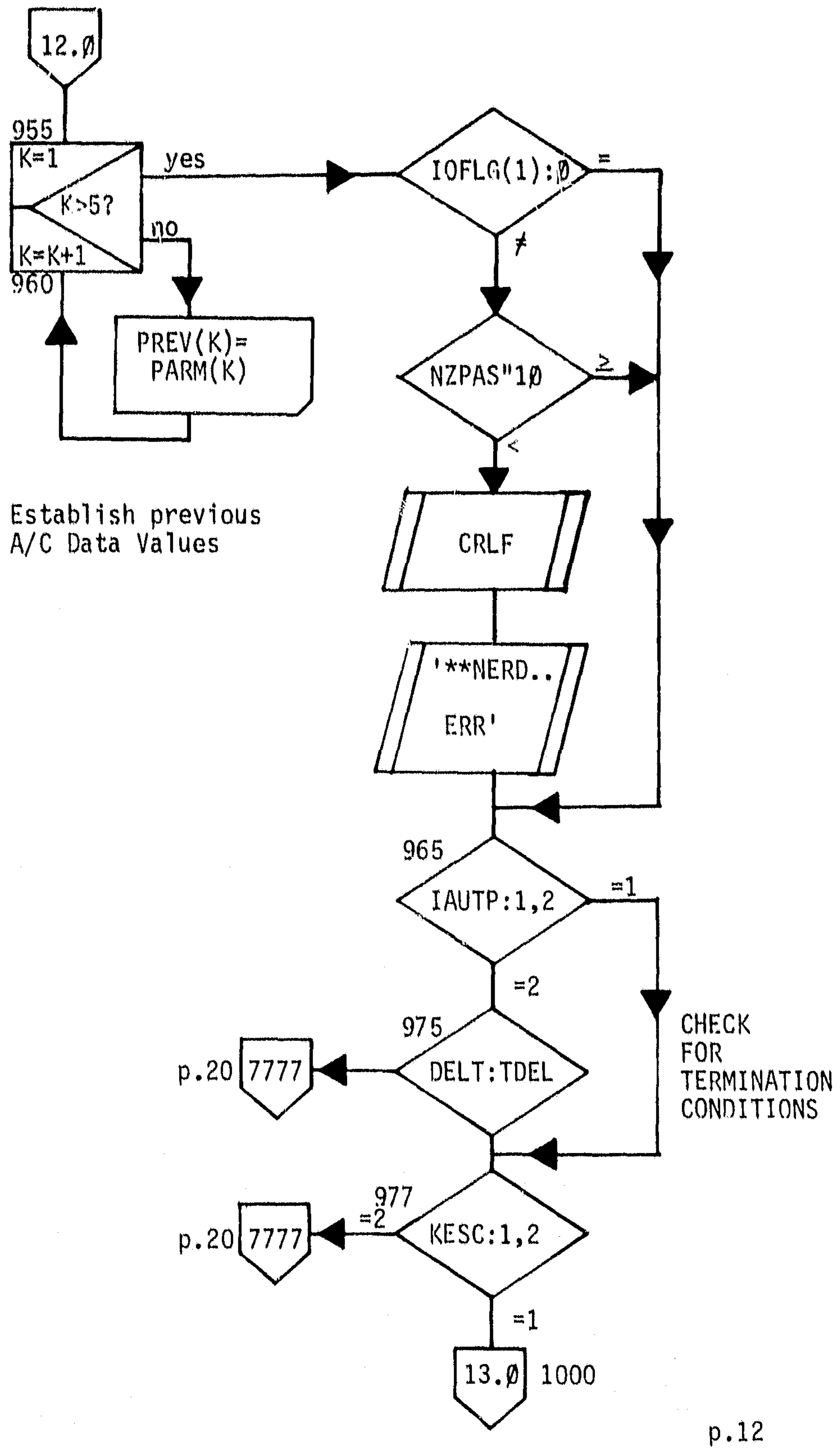


10.Ø
870
READY TO RUN OPTION
READ KEYBOARD
IRESP(1): 'N'
=
1.Ø
40
≠
900
INZ←2
11.Ø

p..10

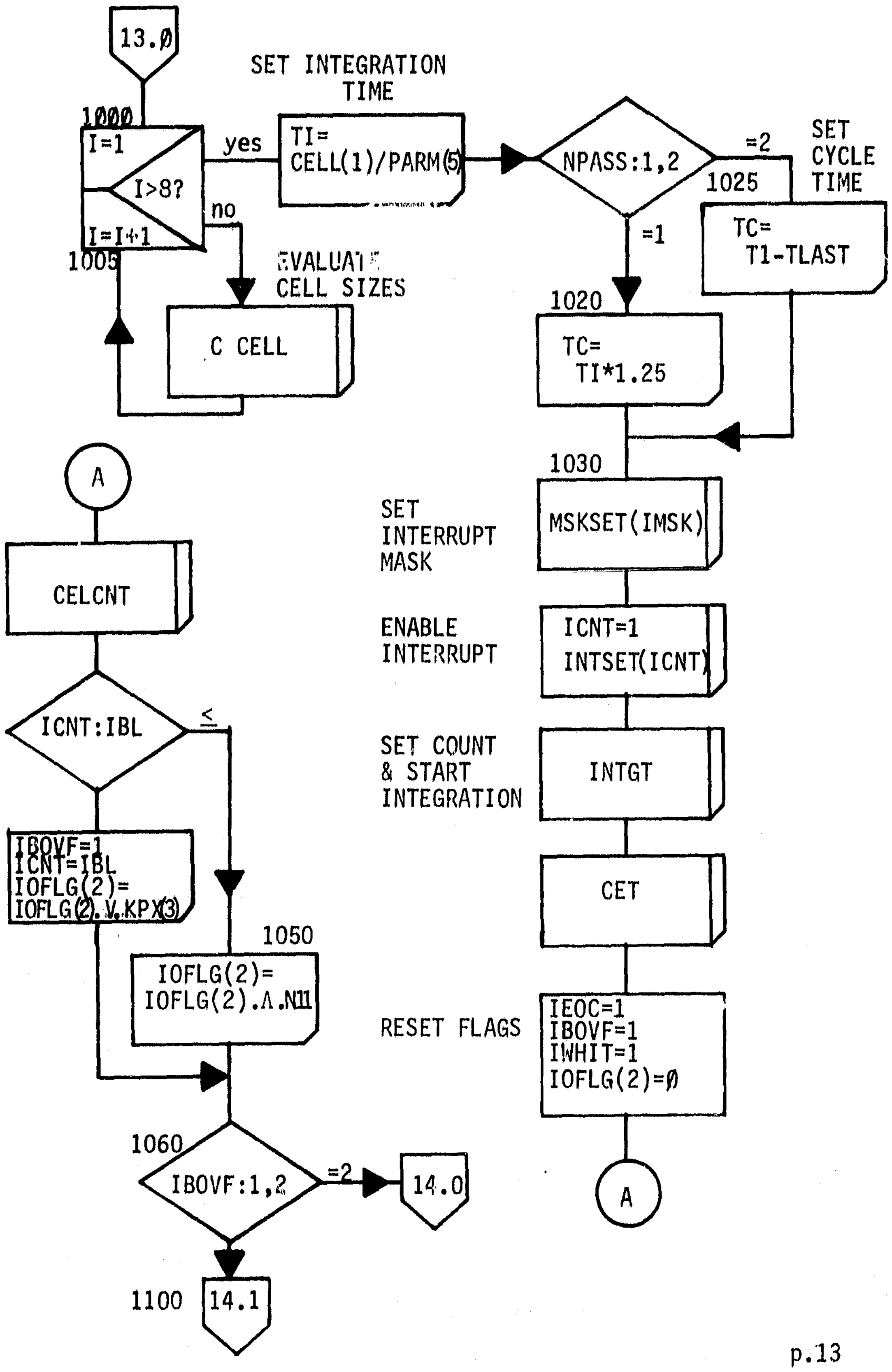
SIGMA1 CALCULATIONS



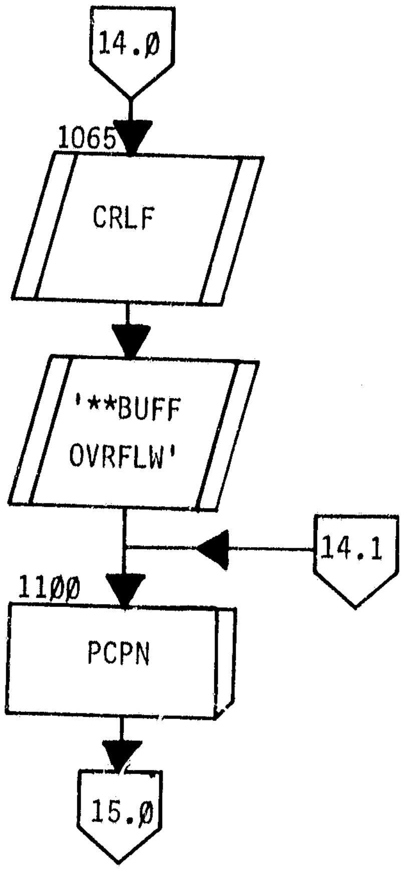


Establish previous
A/C Data Values

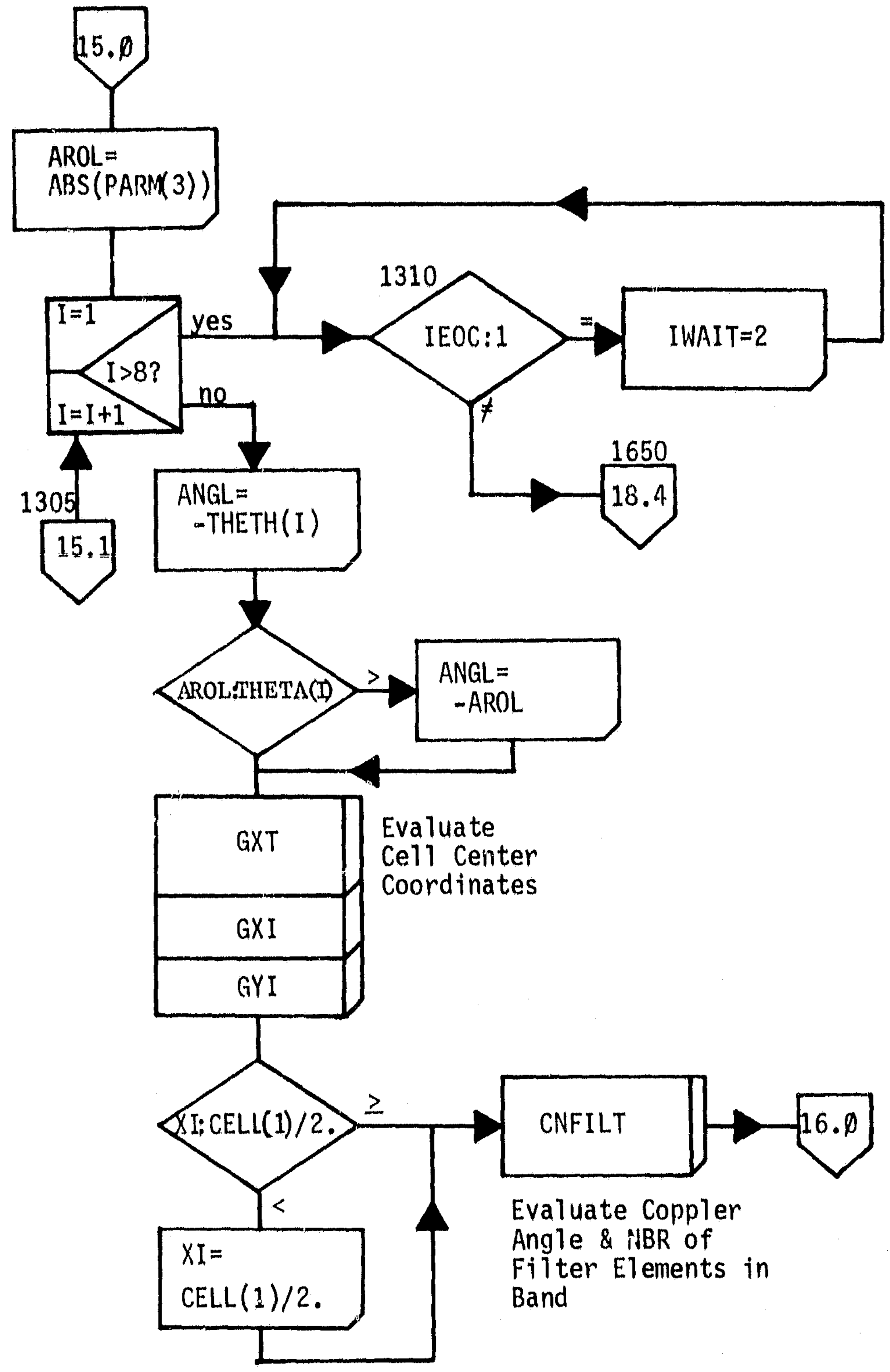
p.12


13.∅
SET INTEGRATION TIME
1000
I=1
I>8?
I=I+1
1005
yes
no
TI=
CELL(1)/PARM(5)
NPASS:1,2
=2
=1
SET CYCLE TIME
1025
TC=
T1-TLAST
EVALUATE CELL SIZES
C CELL
1020
TC=
TI*1.25
1030
SET INTERRUPT MASK
MSKSET(IMSK)
ENABLE INTERRUPT
ICNT=1
INTSET(ICNT)
SET COUNT & START INTEGRATION
INTGT
CET
RESET FLAGS
IEOC=1
IBOVF=1
IWHIT=1
IOFLG(2)=∅
A
A
CELCNT
ICNT:IBL
≤
IBOVF=1
ICNT=IBL
IOFLG(2)=
IOFLG(2).V.KPX(3)
1050
IOFLG(2)=
IOFLG(2).Λ.N11
1060
IBOVF:1,2
=2
14.0
1100
14.1

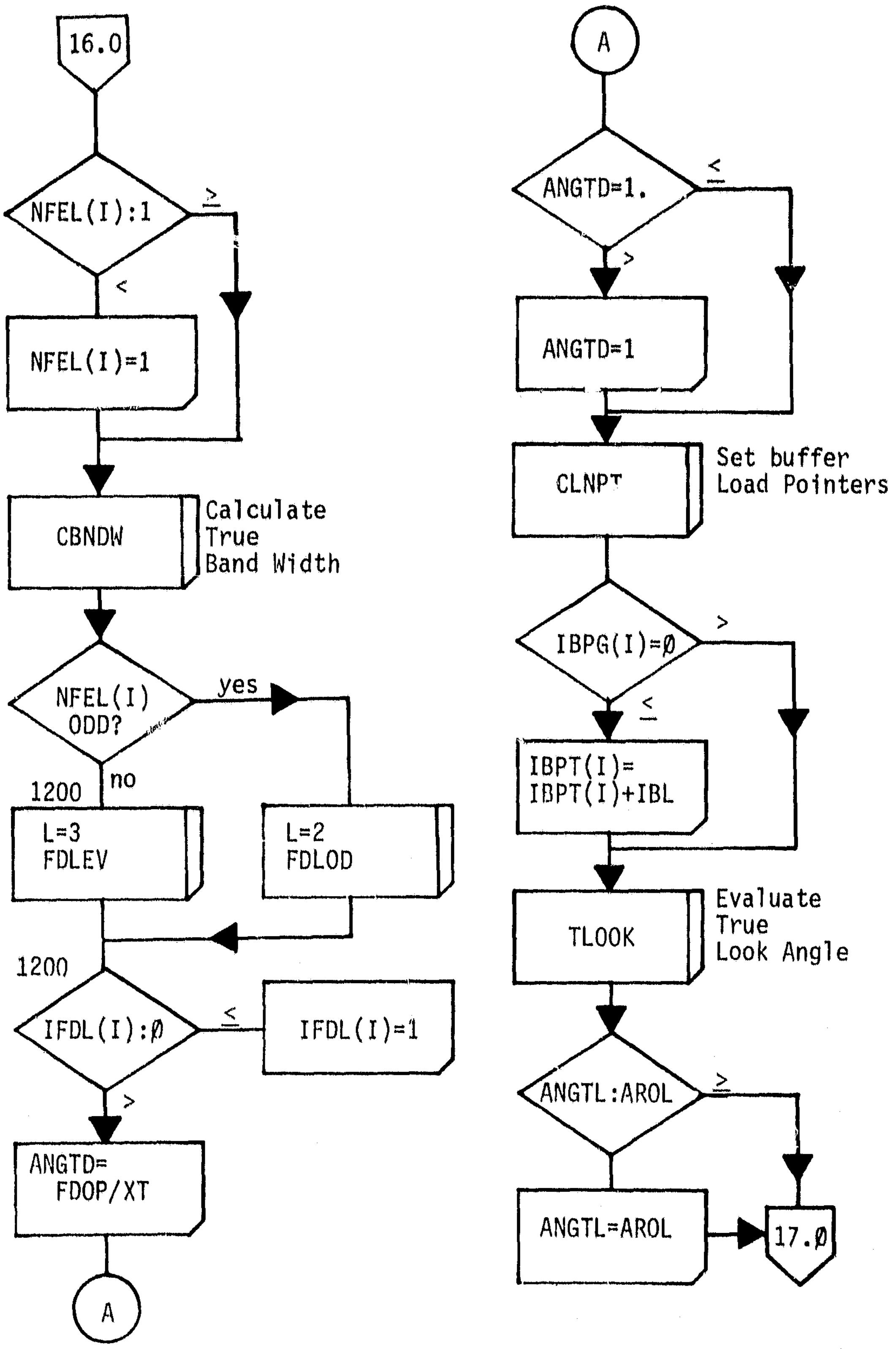
p.13



p.14

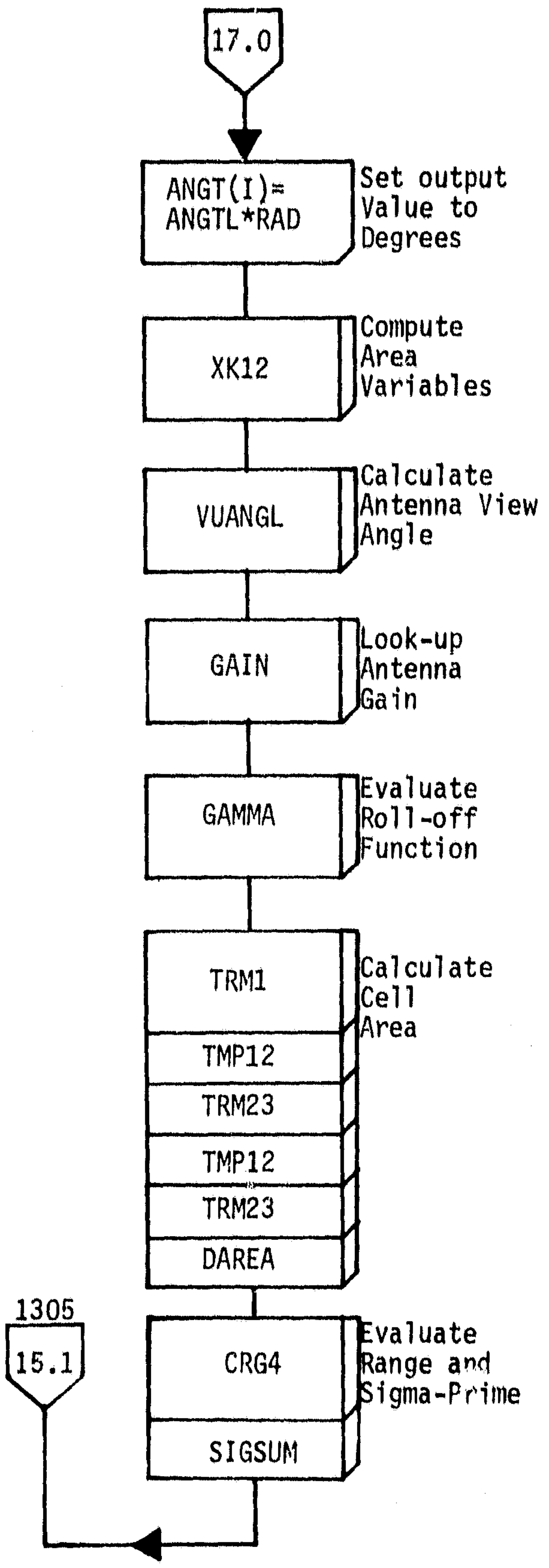

15.Ø
AROL=
ABS(PARM(3))
I=1
I>8?
I=I+1
yes
no
1310
IEOC:1
=
IWAIT=2
≠
1650
18.4
1305
15.1
ANGL=
-THETH(I)
AROL:THETA(I)
>
ANGL=
-AROL
GXT
GXI
GYI
Evaluate
Cell Center
Coordinates
XI:CELL(1)/2.
≥
<
CNFILT
16.Ø
XI=
CELL(1)/2.
Evaluate Coppler
Angle & NBR of
Filter Elements in
Band

p.15

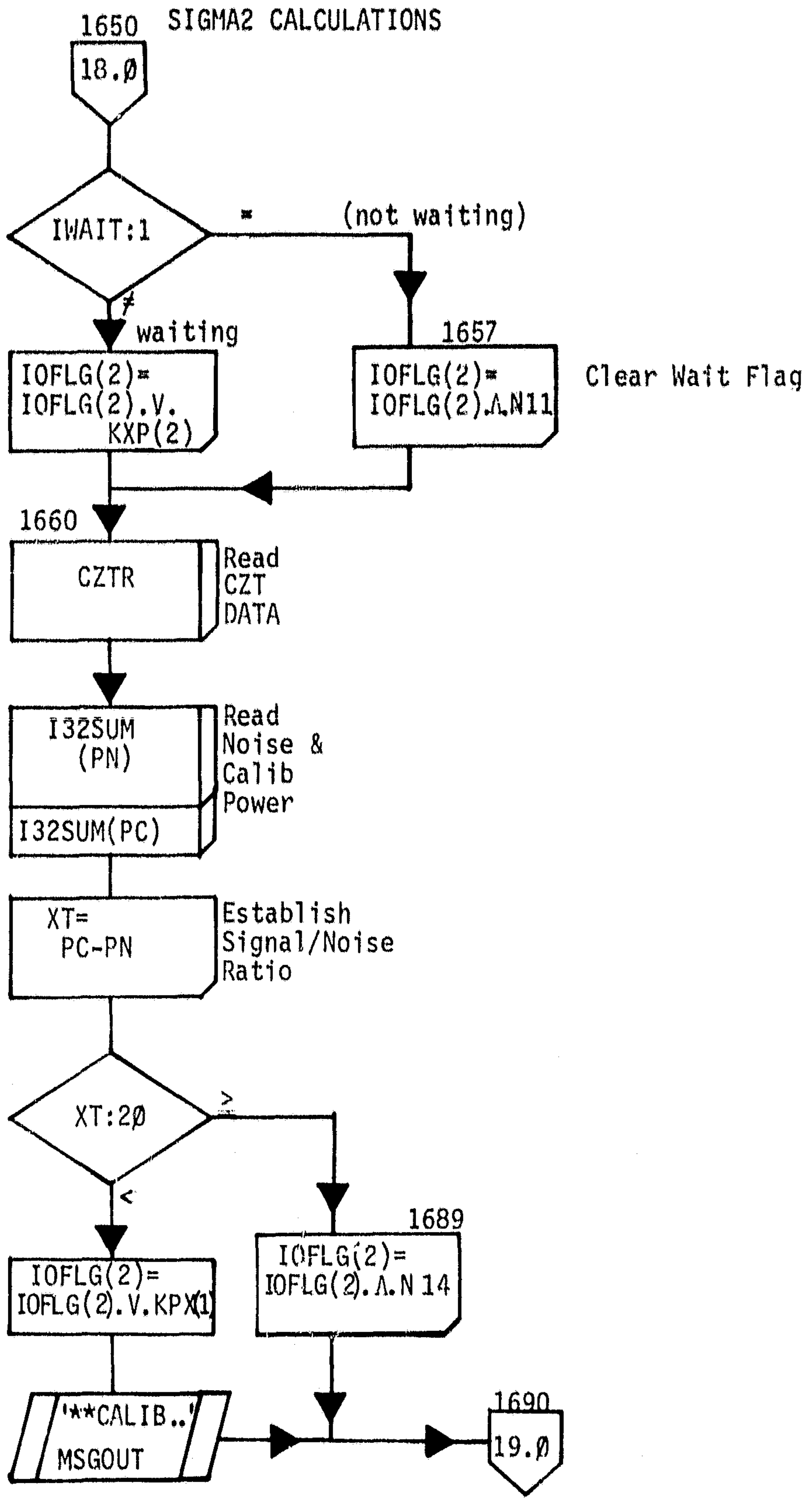


16.0
NFEL(I):1
≥
<
NFEL(I)=1
CBNDW
Calculate True Band Width
NFEL(I) ODD?
yes
no
1200
L=3 FDLEV
L=2 FDLOD
1200
IFDL(I):Ø
≤
IFDL(I)=1
>
ANGTD= FDOP/XT
A
A
ANGTD=1.
≤
>
ANGTD=1
CLNPT
Set buffer Load Pointers
IBPG(I)=Ø
>
≤
IBPT(I)= IBPT(I)+IBL
TLOOK
Evaluate True Look Angle
ANGTL:AROL
≥
ANGTL=AROL
17.Ø

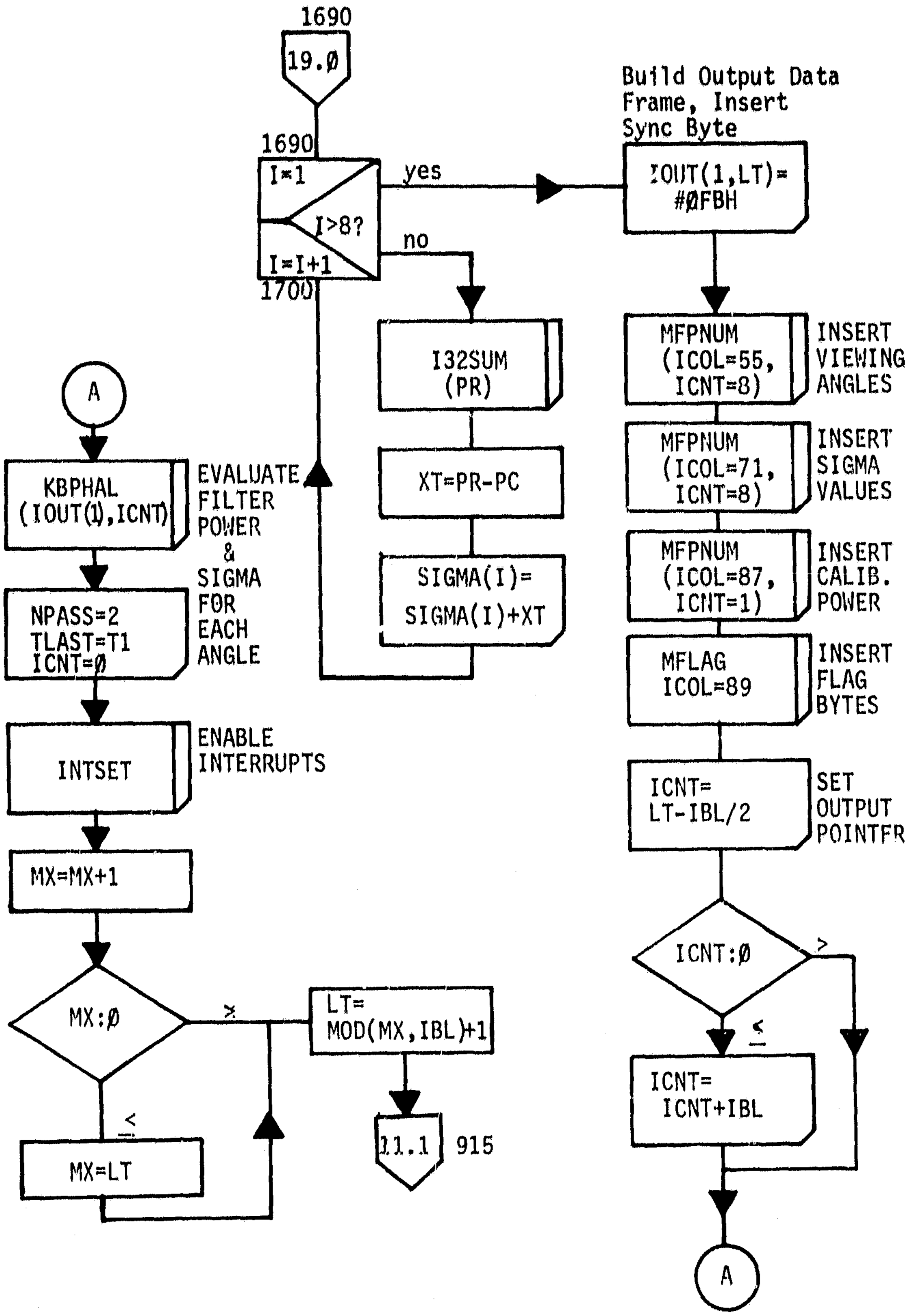
p.16


17.0
ANGT(I)=
ANGTL*RAD
Set output Value to Degrees
XK12
Compute Area Variables
VUANGL
Calculate Antenna View Angle
GAIN
Look-up Antenna Gain
GAMMA
Evaluate Roll-off Function
TRM1
TMP12
TRM23
TMP12
TRM23
DAREA
Calculate Cell Area
1305
15.1
CRG4
SIGSUM
Evaluate Range and Sigma-Prime

p.17

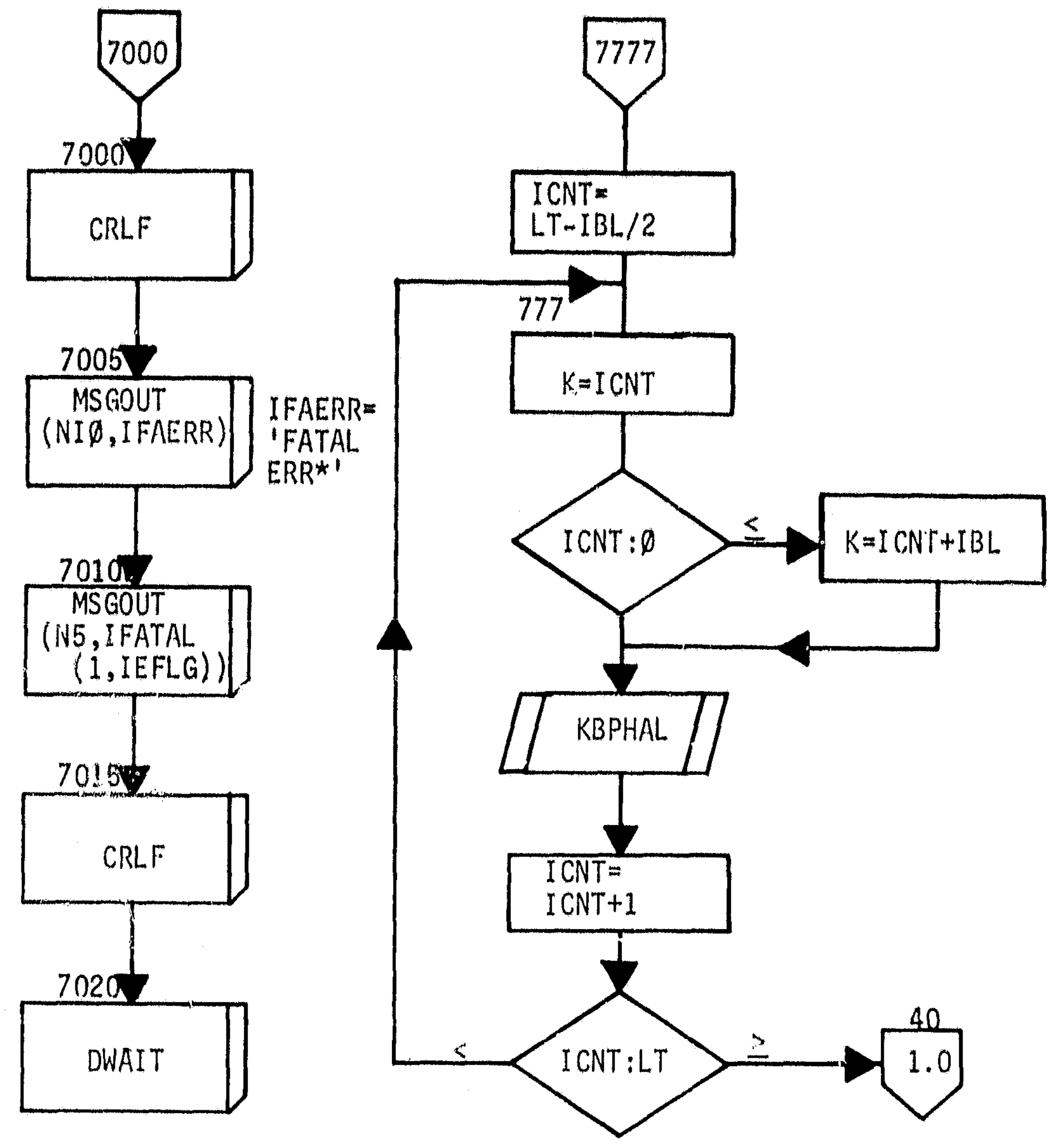

1650
SIGMA2 CALCULATIONS
18.Ø
IWAIT:1
=
(not waiting)
≠
waiting
IOFLG(2)=
IOFLG(2).V.
KXP(2)
1657
IOFLG(2)=
IOFLG(2).Λ.N11
Clear Wait Flag
1660
CZTR
Read
CZT
DATA
I32SUM
(PN)
I32SUM(PC)
Read
Noise &
Calib
Power
XT=
PC-PN
Establish
Signal/Noise
Ratio
XT:2Ø
≥
<
1689
IOFLG(2)=
IOFLG(2).V.KPX(1)
IOFLG(2)=
IOFLG(2).Λ.N 14
'**CALIB..'
MSGOUT
1690
19.Ø

p.18


1690
19.Ø
1690
I=1
I>8?
I=I+1
1700
yes
no
Build Output Data Frame, Insert Sync Byte
IOUT(1,LT)= #ØFBH
I32SUM (PR)
XT=PR-PC
SIGMA(I)= SIGMA(I)+XT
MFPNUM (ICOL=55, ICNT=8)
INSERT VIEWING ANGLES
MFPNUM (ICOL=71, ICNT=8)
INSERT SIGMA VALUES
MFPNUM (ICOL=87, ICNT=1)
INSERT CALIB. POWER
MFLAG ICOL=89
INSERT FLAG BYTES
ICNT= LT-IBL/2
SET OUTPUT POINTER
ICNT:Ø
>
≤
ICNT= ICNT+IBL
A
A
KBPHAL (IOUT(1),ICNT)
EVALUATE FILTER POWER & SIGMA FOR EACH ANGLE
NPASS=2 TLAST=T1 ICNT=Ø
INTSET
ENABLE INTERRUPTS
MX=MX+1
MX:Ø
≥
<
MX=LT
LT= MOD(MX,IBL)+1
11.1
915

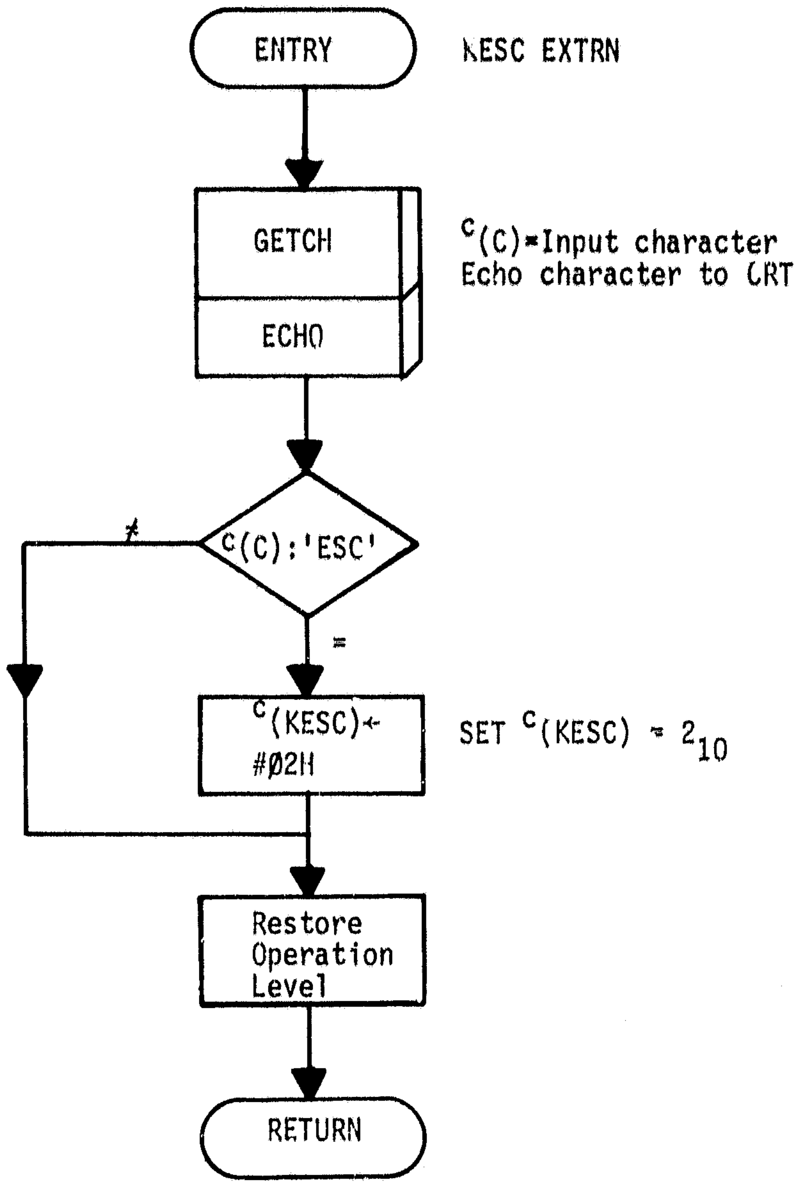
p.19

ERROR MESSAGE HANDLER, INTCOM MODULE



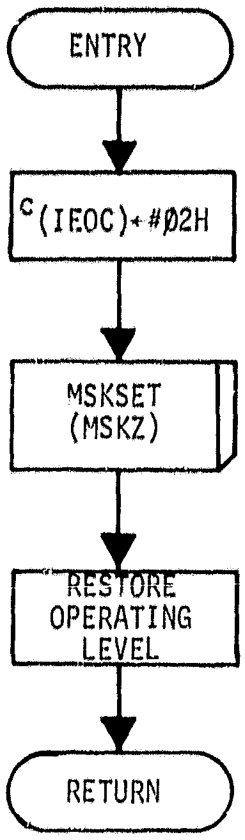
p.20

KEYBOARD INTERRUPT HANDLER



p.21

CZT Board Interrupt Handler



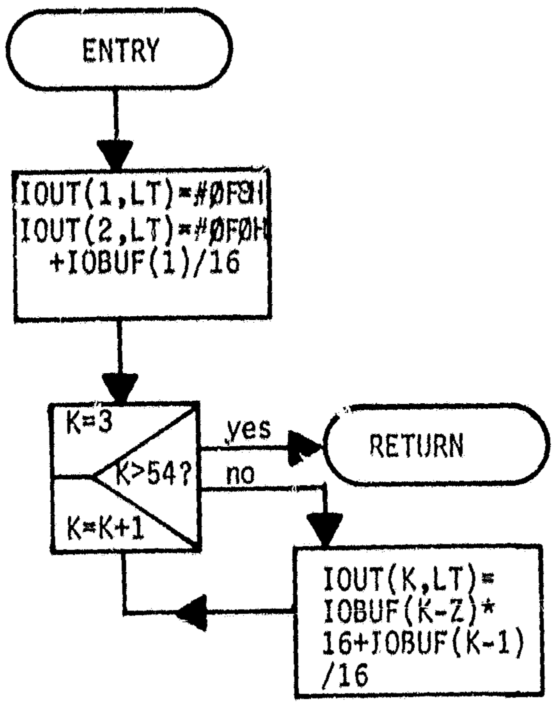
IEOC EXTRN

Set flag signalling that Integration is done

Set Interrupt Mask to inhibit CZT-board

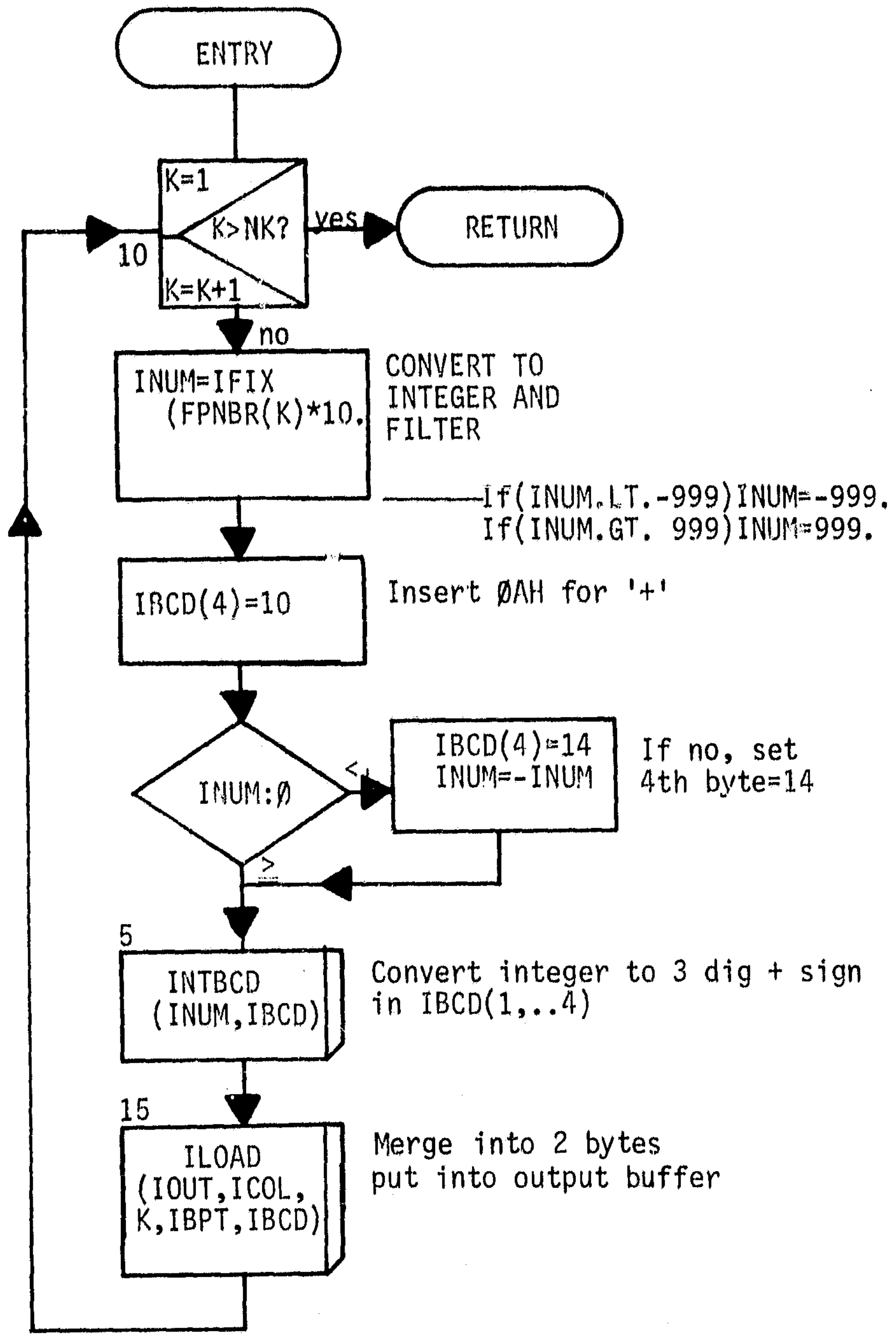
Send End of Interrupt

SUBROUTINE MVNERD(IOUT, IOBUF)
where IOUT(128,70) and IOBUF(60)
are integer*1



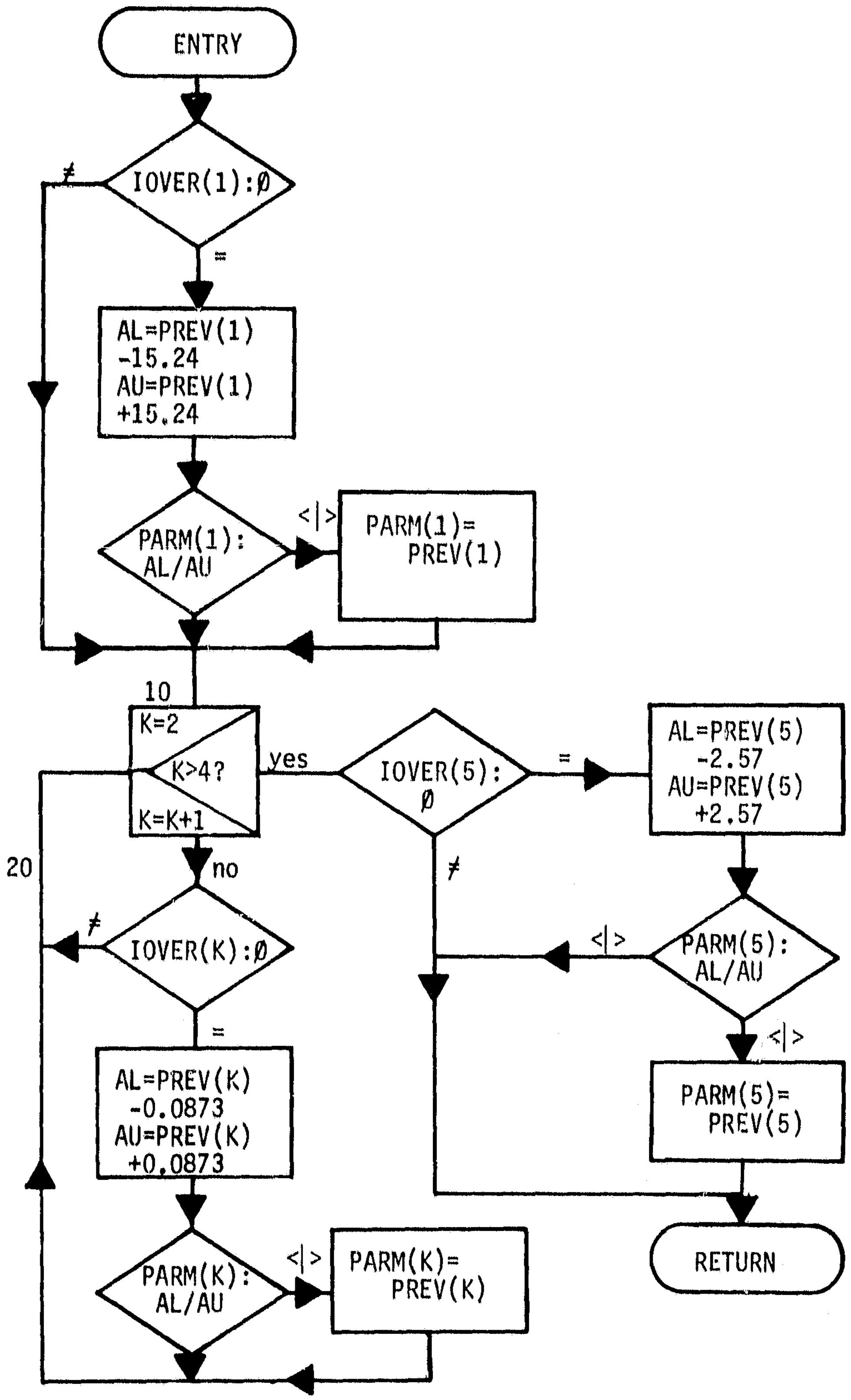
p.23

MFPNUM


ENTRY
K=1
K>NK?
yes
RETURN
10
K=K+1
no
INUM=IFIX (FPNBR(K)*10.
CONVERT TO INTEGER AND FILTER
If(INUM.LT.-999)INUM=-999.
If(INUM.GT. 999)INUM=999.
IBCD(4)=10
Insert ØAH for '+'
INUM:Ø
<
IBCD(4)=14
INUM=-INUM
If no, set 4th byte=14
≥
5
INTBCD (INUM,IBCD)
Convert integer to 3 dig + sign in IBCD(1,..4)
15
ILOAD (IOUT,ICOL, K,IBPT,IBCD)
Merge into 2 bytes put into output buffer

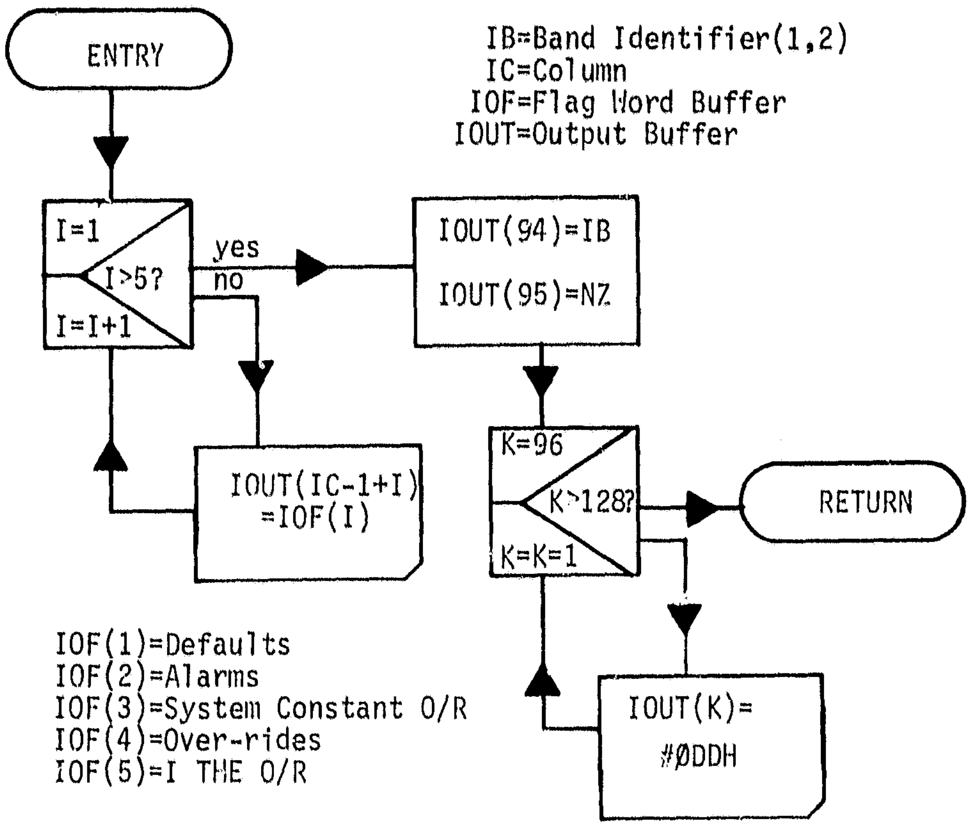
p.24

SUBROUTINE RUNLMT(PREV,PARM,IOVER)
PREV(5), PARM(5), IOVER(5)



p.25

MFLAG SUBROUTINE



BIT ASSIGNMENT:

IOF(1),IOF(3)

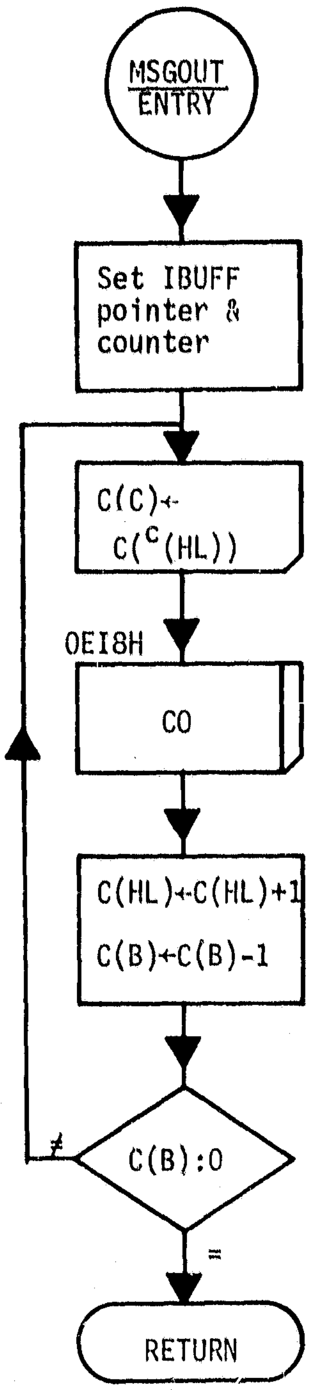
BIT	
0	VEL
1	PITCH
2	ROLL
3	DRIFT
4	ALT
5	X
6	X
7	X

IOF(2)

BIT	
0	BUFFER OVERFLOW
1	WPIT FLAG
2	CALIBRATION ALARM
3	X
4	X
5	X
6	X
7	X

p.26

Message Output to Console, Fortran Callable
MSGOUT(ICNT, IBUFF)



Register:
  C(BC)=adds of char.count
  C(DE)=adds of output strings

C(HL) C(DE), sets pointer
C(A) C(C(BC)), gets count
C(B) C(A),set counter (Ø7FH)

Get a character from the buffer.

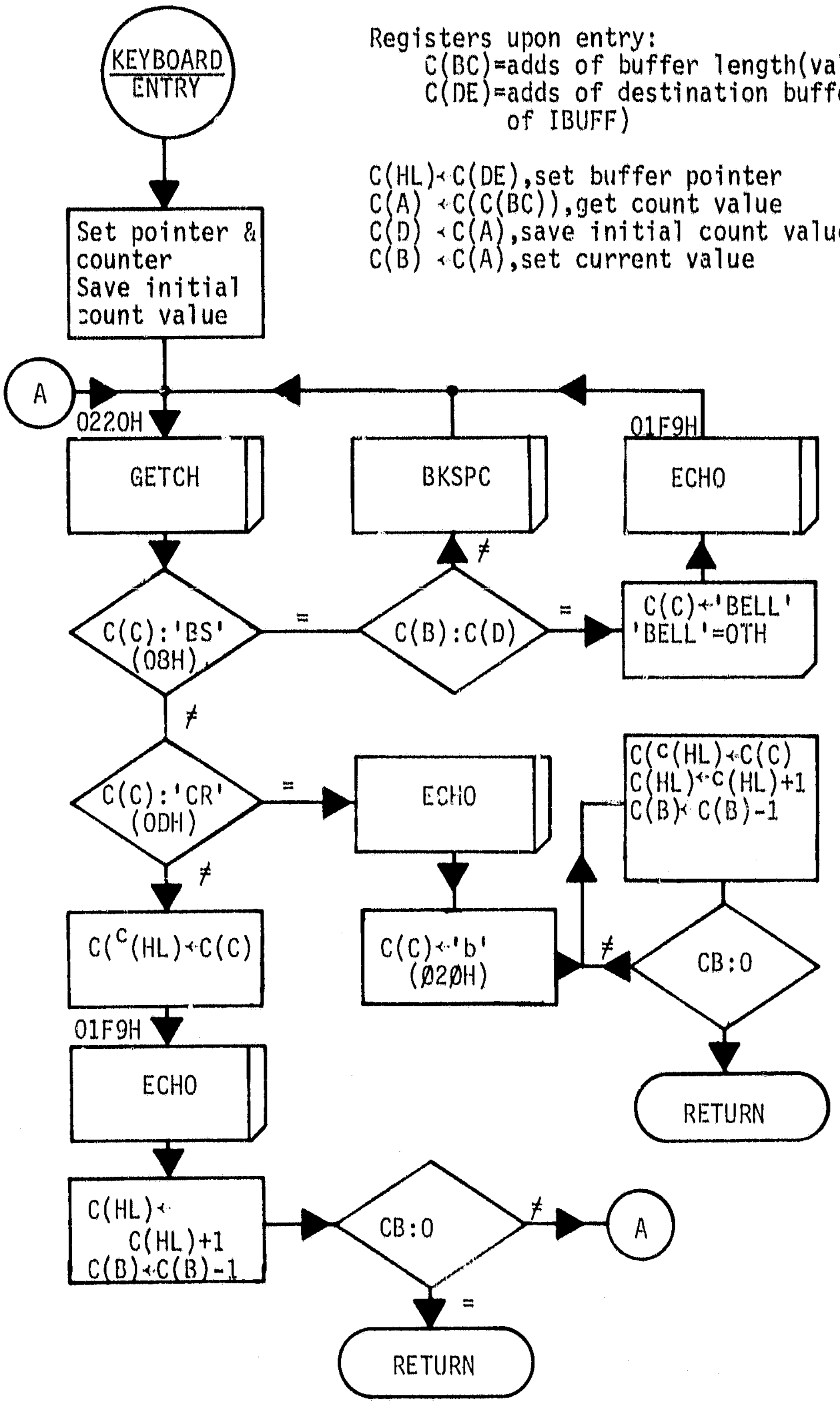
Send character in Reg C to console.

Step adds pointer
Decrement count

Last of String?

p.27

CONSOLE INPUT ROUTINE: KEYBRD(NBR, IBUFF)

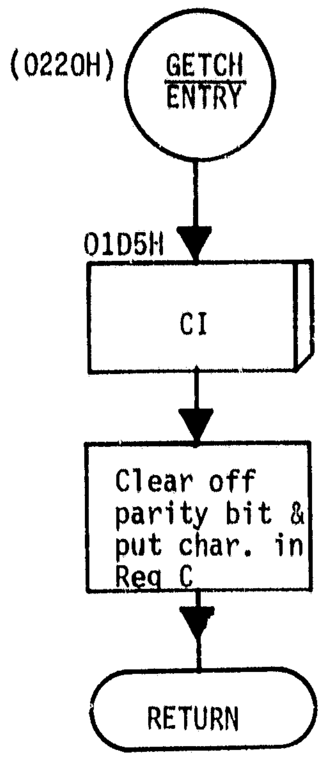


Registers upon entry:
C(BC)=adds of buffer length(value of NBR)
C(DE)=adds of destination buffer (value of IBUFF)

C(HL)←C(DE),set buffer pointer
C(A) ←C(C(BC)),get count value
C(D) ←C(A),save initial count value
C(B) ←C(A),set current value

p.28

Get Character from Input Terminal



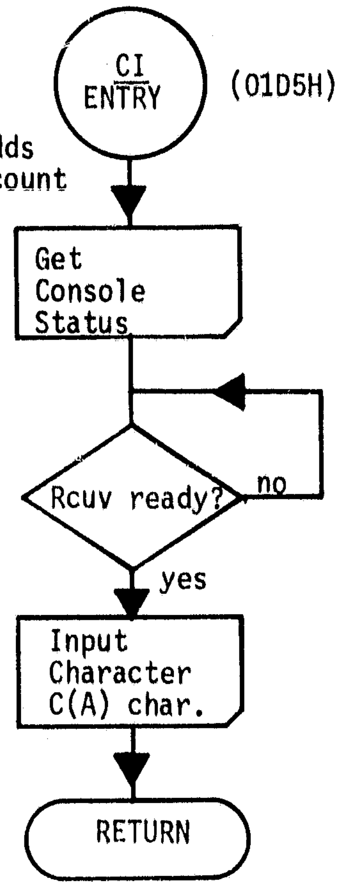
Registers;
    C(HL)= Input buffer adds pointer
    C(B) = current char. count

Call char. input routine
C(A)←'char'

ANI 07FH
C(C)←C(A)

CONSOLE INPUT

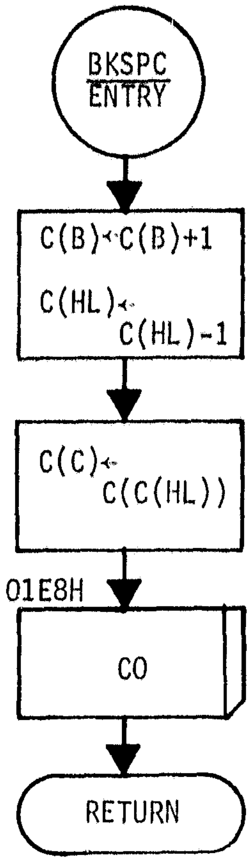
Registers:
    C(HL)=Input buffer adds
    C(B) =Current char. count



```
IN OCDH

ANI OZH
JZ CI

IN CC

RET
```

p.29

BACKSPACE OR RUBOUT



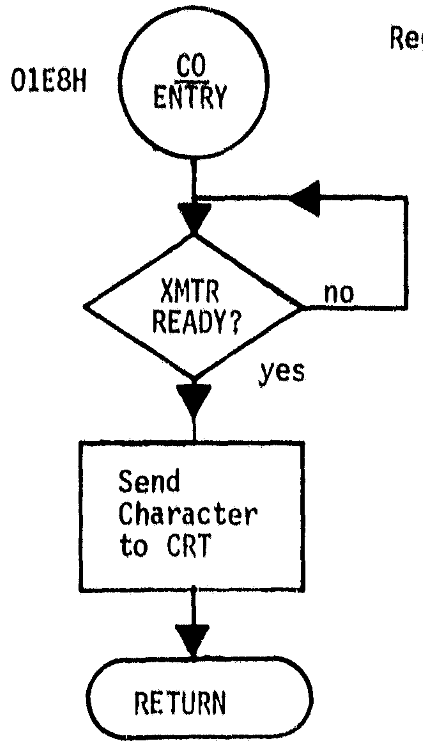
```
Registers:
  C(HL) = pointer to input buffer
C(IBNT) = initial character count
   C(B) = current initial character count
   C(C) = input char. value ('BS')
```

Increment character counter by on.
Set pointer to prior input buffer character.

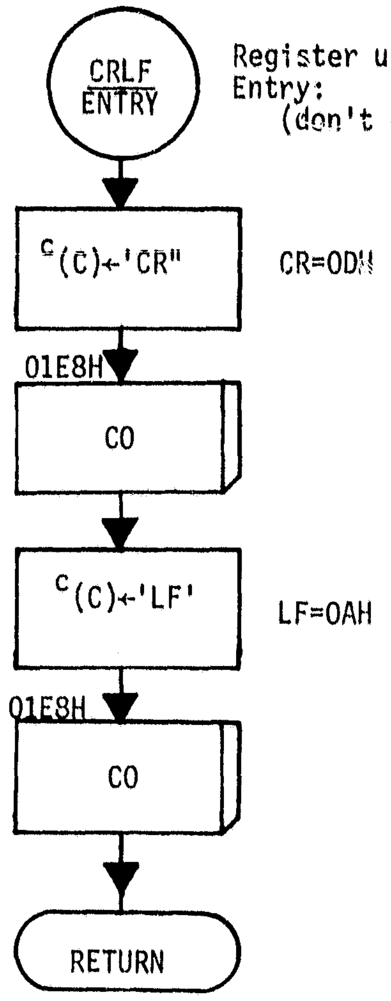
Get prior char. from buffer.

Send previous character to CRT.

Console Output Routine



Registers upon entry:
    c(C)=character to be sent



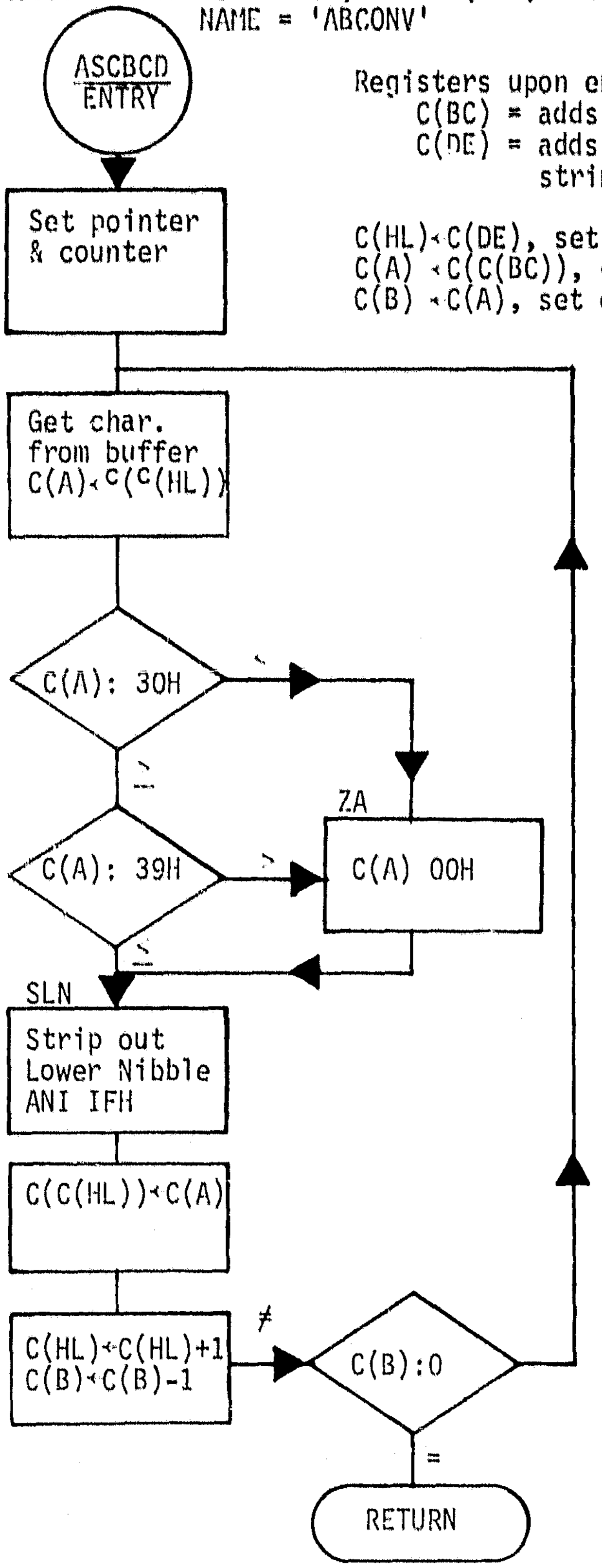
Register upon Entry:
    (don't care)

p.31

ASCII to BCD Converter, ASCBCD(NBR, IBUFF)
NAME = 'ABCONV'

Registers upon entry;
C(BC) = adds of counts value
C(DE) = adds of buffer containing string

C(HL)←C(DE), set pointer
C(A) ←C(C(BC)), get count value
C(B) ←C(A), set counter

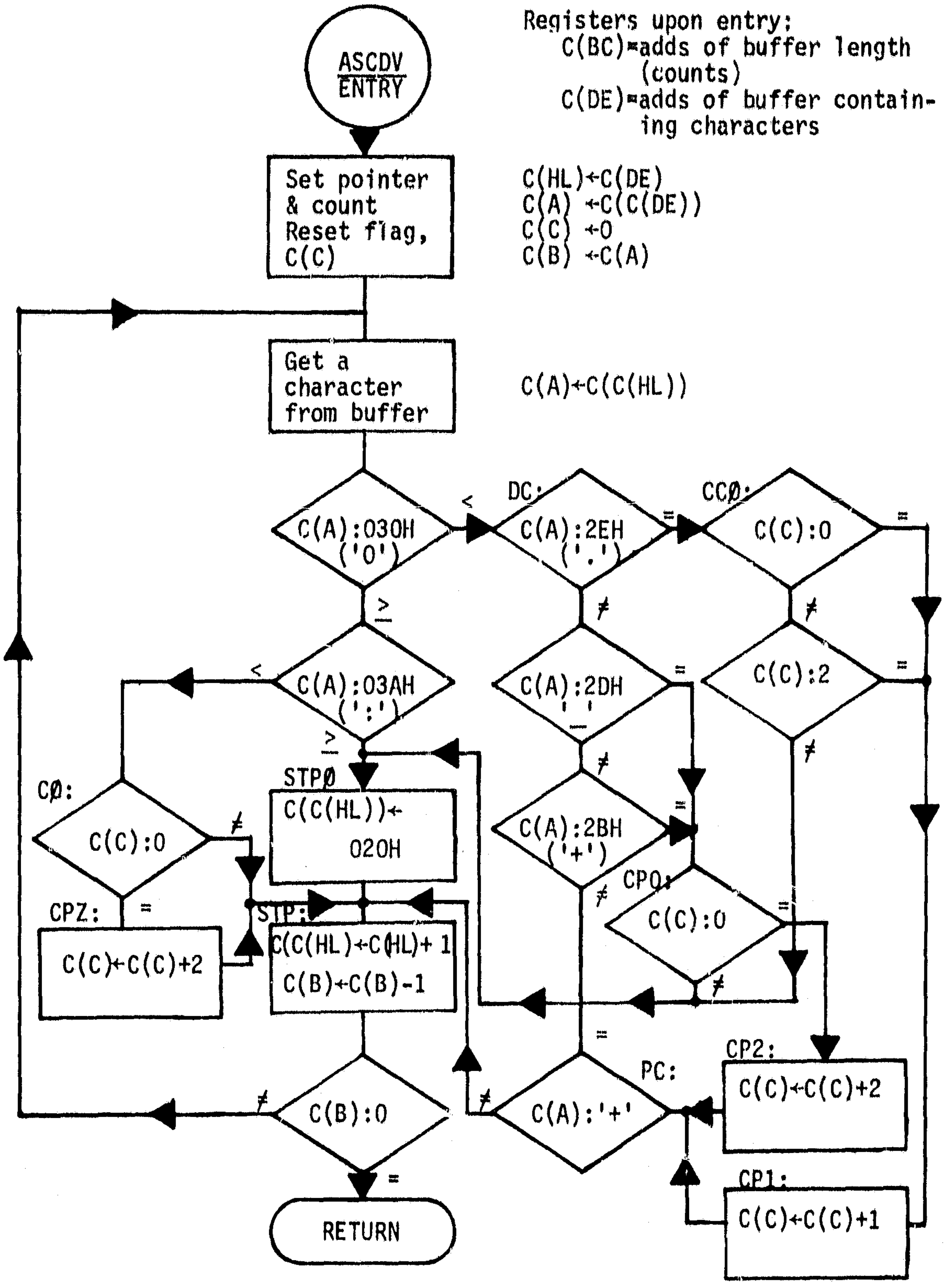


If character is < '0' or if character is > '9' replace it with BCD '0'.

Replace ASCII character in the string with BCD value.

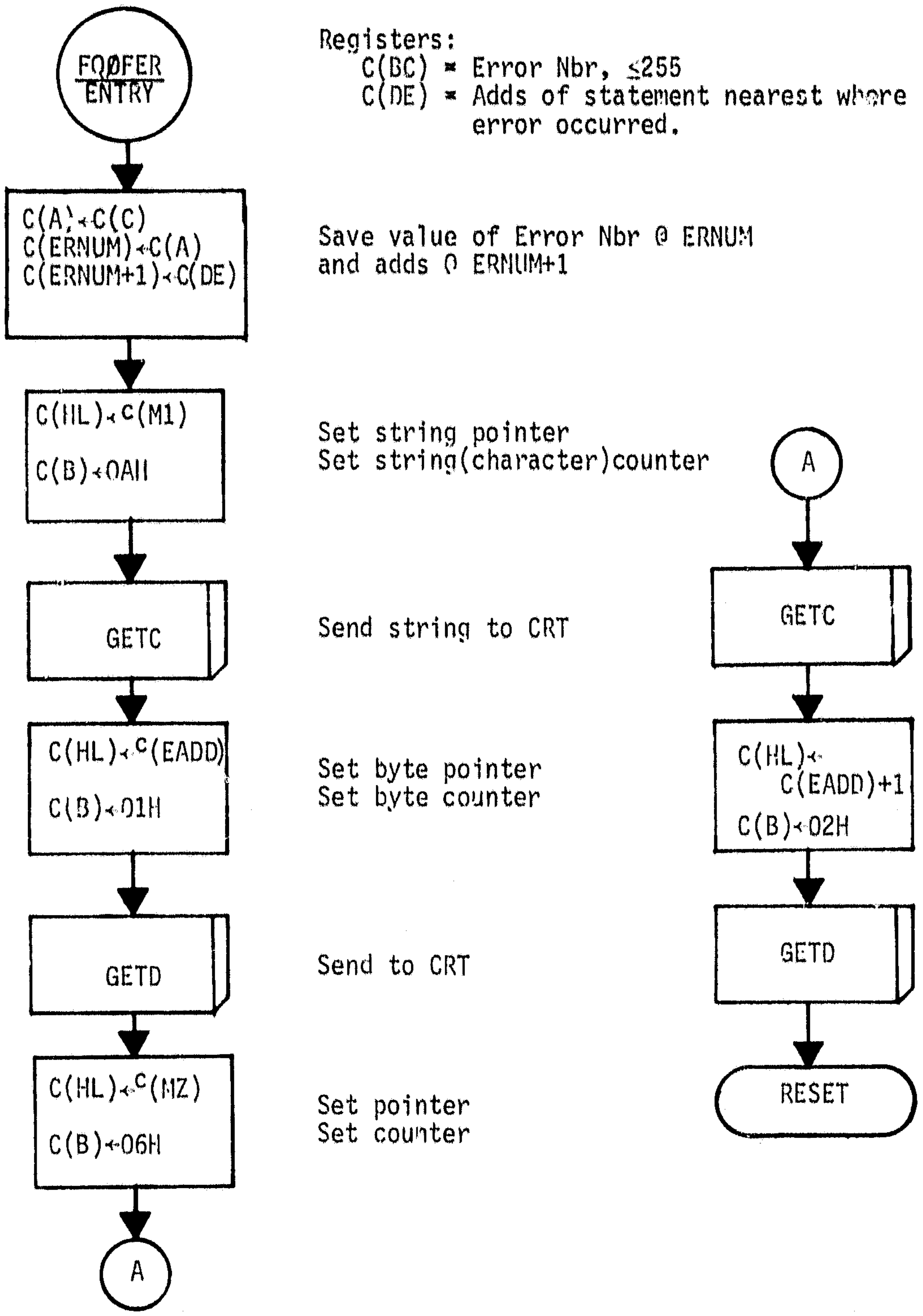
p.32

ASCII Decimal Verification Routine, ASCDV(NBR, IBUFF)



p.33

FORTRAN Run-Time Error Recovery



Registers:
C(BC) = Error Nbr, ≤255
C(DE) = Adds of statement nearest where error occurred.

Save value of Error Nbr @ ERNUM and adds @ ERNUM+1

Set string pointer
Set string(character)counter

Send string to CRT

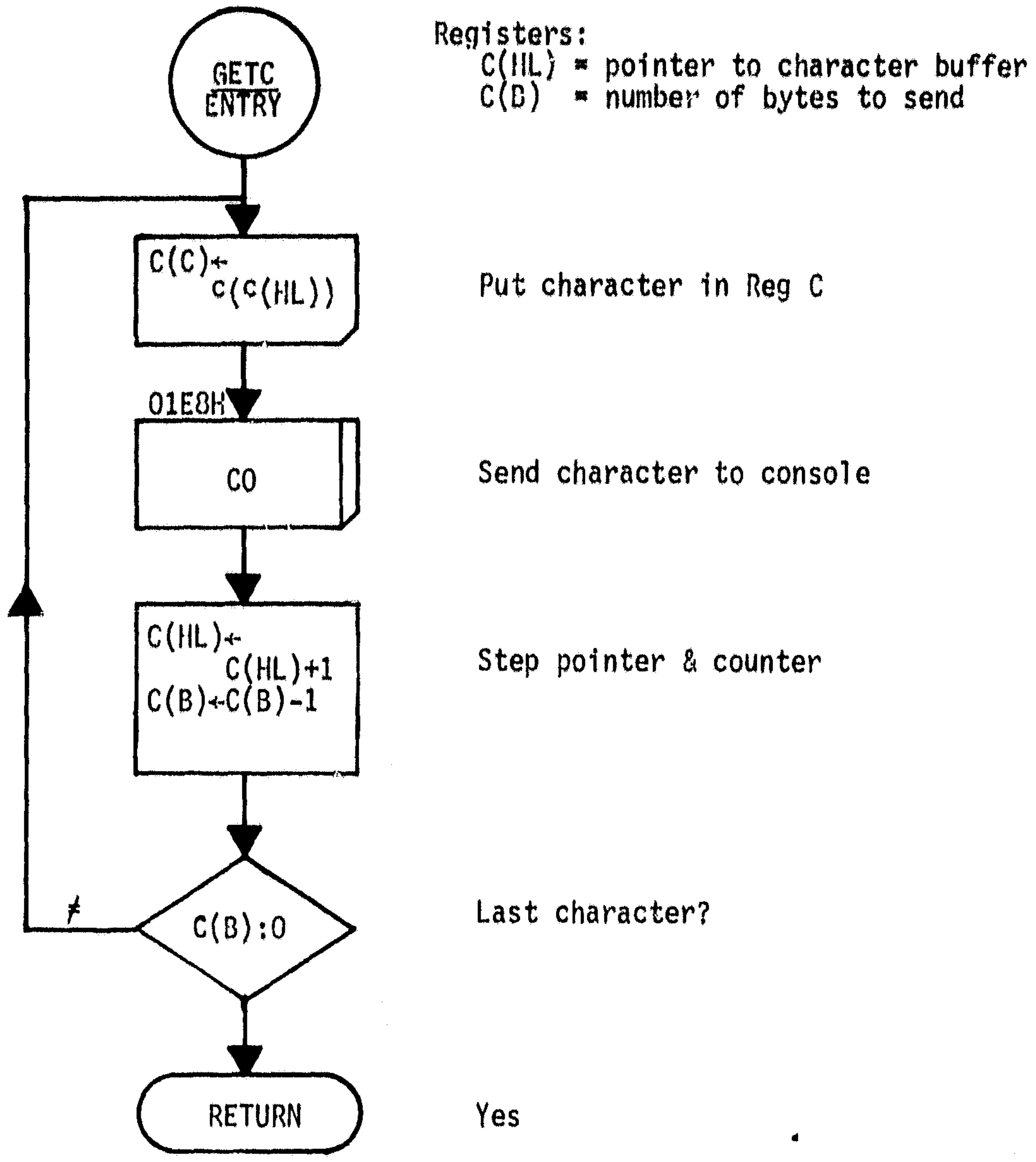
Set byte pointer
Set byte counter

Send to CRT

Set pointer
Set counter

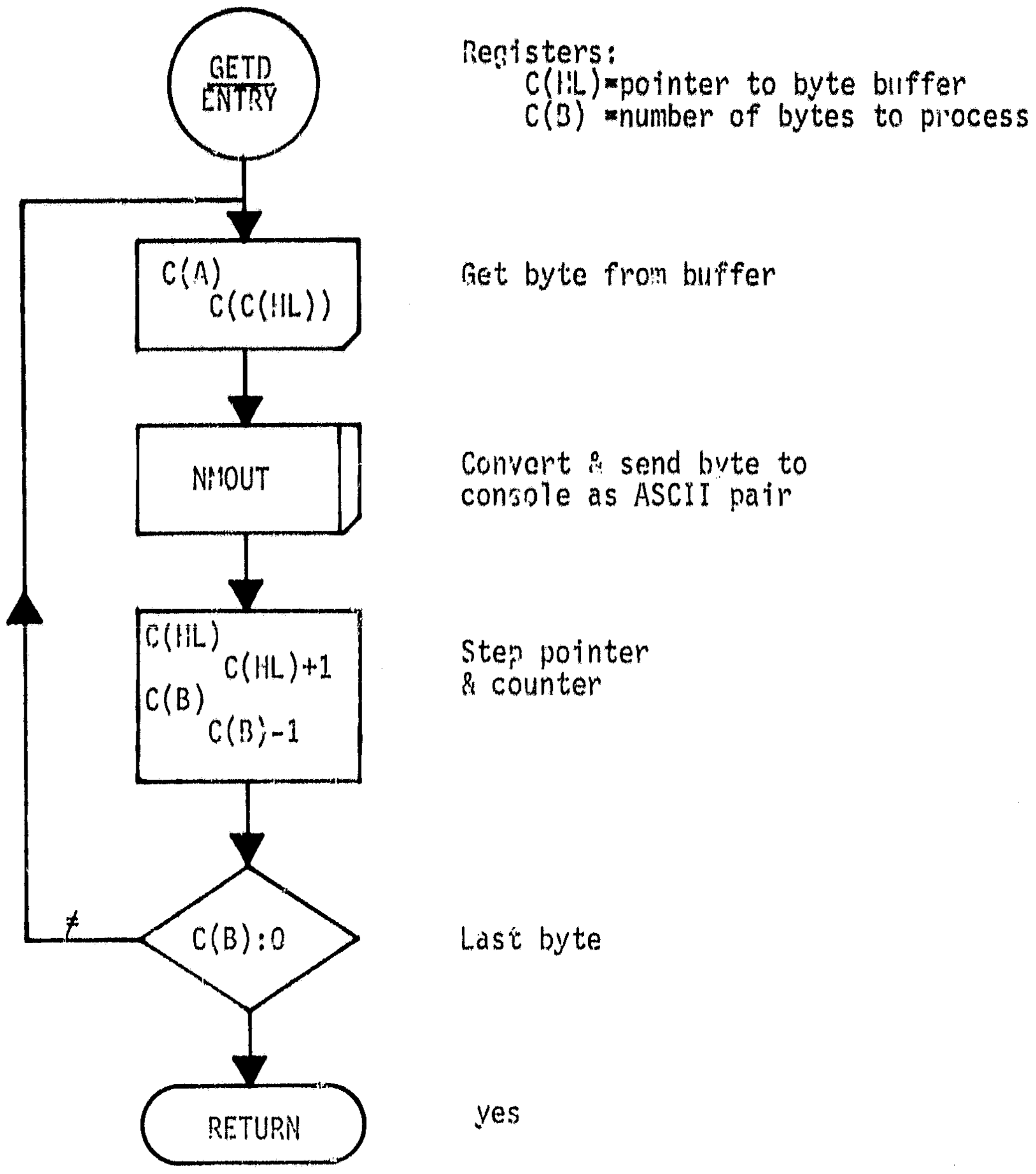
p.34

FORTRAN Run-Time Error Recovery (cont.)
GETC, sends character string to terminal.
co routine resides in Monitor.



p.35

FORTRAN Run-Rime Error Recovery (cont.)
GETD, converts byte to ASCII character pair
NMOUT routine resides in Monitor



p.36

APPENDIX B

INTCOM Listing (Main Driver)

TI-980 FORTRAN V4L1

```
C::::::::::::::PARAMETER DEFINITIONS::::::::::::::::::::::C
C                                                         C
C        C/L-BAND SCATTEROMETER PROCESSOR                 C
C
C        TEXAS A&M UNIVERSITY REMOTE SENSING CENTER        C
C
C:::::::::::::::::::::::::::::::::::::::::::::::::::::::::C
C
C      ANGL      VIEWING ANGLE, ALWAYS AFT,ANTENNA TO GROUND CELL.
C      ANGT      VIEWING ANGLE, IN DEGREES, USED IN OUTPUT FRAME.
C      AROL      ABSOLUTE VALUE OF AIRCRAFT ROLL, RADIANS.
C      BMW       BEAM WIDTH OF ANTENNA, BAND DEPENDENT, RADIANS.
C      BMWID     BEAM WIDTH CONSTANT, BAND DEPENDENT, DEGREES.
C      BNDW      BAND WIDTH VARIABLE USED FOR EACH FILTER.
C      CANT1     ANTENNA GAIN CONSTANT, USED FOR C-BAND.
C      CANT2       "       "      "       "    "    "
C      CANT3       "       "      "       "    "    "
C      CANT4       "       "      "       "    "    "
C      CC        TWO DIMENSIONAL CONSTANT BUFFER USED FOR ROLL-OFF.
C      CCLC      CHARACTER BUFFER FOR 'L' AND 'C'.
C      CELL      CELL SIZE, METERS, 8 VALUES.
C      CFAERR    ERROR MESSAGE BUFFER.
C      CFATAL      "      "      "
C      CILC      CHARACTER BUFFER FOR 'L','C'.
C      CIOBUF    I/O BUFFER, EQUIVALENCED TO CRESP.
C      CIOVRG    CHARACTER BUFFER USED FOR OVER-RIDE INPUTS.
C      CIPOLZ      "         "      "    " POLARIZATION  ".
C      CIYN      "         "  "     " OPERATOR RESPONSES.
C      CL        L-BAND ROLL-OFF POLYNOMIAL CONSTANTS.
C      CNERD     CHARACTER BUFFER, EQUIVALENCED TO CRESP.
C      CRESP       "         "    , GENERAL I/O USAGE.
C      CST       GENERAL CONSTANT DATA BUFFER.
C      DELF      FILTER SPECTRAL LINE-WIDTH, BAND DEPENDENT.
C      DELT      DATA ACQUISITION AND RUN TIME, OPERATOR SETS.
C      DFALT     AIRCRAFT NERDAS DEFAULT VALUES.
C      DIFF      DIFFERENCE BETWEEN VIEWING AND RESOLUTION ANGLE.
C      DLIM      LOWER AND UPPER LIMITS FOR INPUT NERDAS DATA.
C      DTHEI     INPUT VALUE OF RESOLUTION ANGLE, OPERATOR SETS.
C      DTHER     RADIAN VALUE OF      "          "   USED IN EXECUTION.
C      DTHETA    DEFAULT VALUE OF RESOLUTION ANGLE, BAND DEPENDENT.
C      FCAL      CALIBRATION TONE FREQUENCIES, BAND DEPENDENT.
C      FDOP      DOPPLER CENTER FREQUENCY FOR FILTER.
C      FNOIZ     NOISE FILTER FREQUENCY, BAND DEPENDENT.
C      FPI3L     CONSTANT, BAND DEPENDENT, (4*PI)**3/LAMDA**2.
C      GSQ       GAIN VALUE IN DB, ANTENNA ANGLE RELATED.
C      IAUTP     FLAG SIGNIFYING AUTO-STOP IF SET TO VALUE OF 2.
C      IAUTR       "          "          " -START WHEN SET TO 2.
C      IBCD      BUFFER USED WHEN CONVERTING TO BINARY-CODED DECIMAL.
C      IBFLW     MESSAGE BUFFER OF OVER-FLOW OF OUTPUT BUFFER.
C      IBL       ALLOWABLE BUFFER LENGTH, SET TO 70.
C      IBND      BAND IDENTIFIER, L-BAND=1, C-BAND=2.
```

```
0052  C       IBOVF     FLAG USED TO SIGNAL BUFFER OVERFLOW.
0053  C       IBPT      POINTER FOR POSITIONING DATA IN OUTPUT BUFFER.
0054  C       ICALW     MESSAGE BUFFER FOR CALIBRATION WARNING.
0055  C       ICLC      CHARACTER BUFFER FOR 'L','C'.
0056  C       ICNT      GENERAL PURPOSE INTEGER VARIABLE.
0057  C       IEFLG     POINTER USED TO GET ERROR MESSAGES FOR I/O.
0058  C       IEOC      FLAG USED TO SIGNAL END OF INTEGRATION, CZT BOARD.
0059  C       IERR      FLAG USED TO SIGNAL I/O ERRORS.
0060  C       IFAERR    ERROR MESSAGE BUFFER.
0061  C       IFATAL       "      "      "
0062  C       IFCAL     POINTER TO CALIBRATION TONE FILTER.
0063  C       IFDL      LEFT FILTER POINTER FOR EACH ANGLE.
0064  C       IGTBC     GAIN TABLE FOR C-BAND ANTENNA, INTEGERS.
0065  C       IGTBL       "     "     " L-BAND     "        "
0066  C       ILC       CHARACTER BUFFER FOR 'L','C'.
0067  C       IMSK      MASK BUFFER FOR SETTING INTERRUPTS
0068  C       INERD     CHARACTER BUFFER FOR NERDAS I/O.
0069  C       INZ       INITIALIZATION FLAG.
0070  C       INZERR    MESSAGE BUFFER FOR NERDAS WARNING.
0071  C       IOBUF     GENERAL PURPOSE I/O BUFFER.
0072  C       IOFLG     BUFFER OF FLAG WORDS USED IN OUTPUT DATA SET.
0073  C       IOUT      OUTPUT DATA BUFFER.
0074  C       IOVER     FLAGS USED TO SIGNAL OVER-RIDE CONDITIONS.
0075  C       IOVRQ     MESSAGE BUFFERS USED IN ACQUIRING OVER-RIDE VALUES.
0076  C       IPLZ      CHARACTER BUFFER USED TO IDENTIFY POLARIZATION.
0077  C       IPOLZ     POLARIZATION IDENTIFIERS.
0078  C       IPSD      POWER SPECTRAL DATA BUFFER, 512 INTEGER*4.
0079  C       IRESP     GENERAL PURPOSE I/O BUFFER.
0080  C       IWAIT     FLAG TO SIGNAL COMPLETION OF SIGMA1 TASKS.
0081  C       IYN       CHARACTER BUFFER.
0082  C       I,J,K     DO LOOP INDEXES.
0083  C       KESC      CHARACTER, 'ESCAPE'.
0084  C       KXP       BINARY POWER BUFFER.
0085  C       LANT11    L-BAND ANTENNA GAIN BUFFER.
0086  C       LANT12    "      "        "      "
0087  C       LANT13        "      "       "      "
0088  C       LANT14        "      "       "      "
0089  C       LANT21        "      "       "      "
0090  C       LANT22        "      "       "      "
0091  C       LANT23        "      "       "      "
0092  C       LANT24        "      "       "      "
0093  C       LT        LOAD POINTER FOR OUTPUT BUFFER.
0094  C       MX        OUTPUT POINTER FOR DATA BEING SENT OUT.
0095  C       NC        INTEGER CONSTANT TABLE.
0096  C       NFEL      NUMBER OF FILTER ELEMENTS TO SUM.
0097  C       NPASS     FLAG TO SIGNAL PASS NUMBER.
0098  C       NPZN      POLARIZATION IDENTIFIER NUMBER.
0099  C       NZE       NOISE FILTER ELEMENT COUNTER.
0100  C       NZL       LEFT MOST NOISE FILTER ELEMENT.
0101  C       NZPAS     PASS COUNTER USED FOR CHECKING NERDAS DATA.
0102  C       PARM      BUFFER OF NERDAS AIRCRAFT DATA PARAMETERS.
```

```
0103  C      PC          SUBPARAMETER USED INT EVALUATING SIGMAO.
0104  C      PN               "          "   "      "          "
0105  C      PR               "          "   "      "          "
0106  C                  PC=CALIB POWER, PN=NOISE POWER, PR=RECEIVE POWER
0107  C      PREV        BUFFER TO SAVE PREVIOUS VALUES OF AIRCRAFT DATA
0108  C      RCAL        CALIBRATION FREQUENCY USED, BAND DEPENDENT.
0109  C      RO4         RANGE VALUE IN DB.
0110  C      SIGMA       SIGMA-O VALUES FOR EACH VIEWING ANGLE.
0111  C      SLMDA       WAVE
0112  C      START       TIME IN SECONDS AT WHICH DATA SET STARTS.
0113  C      SUM         POWER SPECTRAL SUM OVER FILTER SET FOR ANGLE.
0114  C      SYSK        SYSTEM PROCESSING CONSTANT.
0115  C      TO          TIME IN SECONDS AT WHICH DATA SET STARTS.
0116  C      T1          CURRENT NERDAS TIME IN SECONDS.
0117  C      T2          VARIABLE USED IN AREA CALCULATION.
0118  C      T3             "       "    "    "       "
0119  C      TANTL       VARIABLE USED IN AREA CALCULATION.
0120  C      TC          MICRO-PROCESSOR CYCLE TIME IN SECONDS.
0121  C      TDEL        ELAPSED TIME COUNTER.
0122  C      THETA       DESIRED VIEWING ANGLES, RADIANS.
0123  C      TI          INTEGRATION TIME, SECONDS.
0124  C      TM1         AREA CALCULATION VARIABLE.
0125  C      XDELF       FILTER LINE WIDTH, BAND DEPENDENT.
0126  C      XI          X-COORD. OF GROUND CELL POSITION.
0127  C      XK1         AREA CALCULATION VARIABLE.
0128  C      XK12          "       "           "
0129  C      XK2          "       "           "
0130  C      XLMDA       WAVE-LENGTH, BAND DEPENDENT.
0131  C      XSYSK       SYSTEM CONSTANT VALUES, BAND/POLARIZATION DEP.
0132  C      XT          VARIABLE USED IN EVALUATION OF CELL LOCATION.
0133  C      YI          Y-COORD. OF GROUND CELL POSITION.
0134  C      ZW          ROLL-OFF VALUE IN DB.
0135  C
0136  C:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

NO END CARD

SUBROUTINE

$F4END

PROGRAM ALLOCATION
```

```
TI-980 FORTRAN  V4L1

PROGRAM END

COMPILER MEMORY USED =  6960

THERE ARE 0001 ERRORS IN THIS COMPILATION.
```

```
ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT INTCOM
OBJECT MODULE PLACED IN :F1:SIGMAO.OBJ
COMPILER INVOKED BY:  FORT80 :F1:SIGMAO.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90) XREF


            PROGRAM INTCOM
      C   FLOATING POINT VARIABLES
      C
            DIMENSION CELL(8),FNOIZ(2),TANTL(8),ANGT(8),XLMDA(2),DTHETA(2),
          & XSYSK(4,2),ACOVR(5),DLIM(5,2),DFALT(5),PARM(5),FCAL(3),
          & THETA(8),START(3),XDELF(2),FPI3L(2),BMWID(2),
          & PREV(5),SIGMA(8)
      C   I/O BUFFERS AND FLAGS
      C
            INTEGER*1 IOBUF(60),INERD(60),IOVER(5),IRESP(30),IOUT(128,70),
          & IFATAL(5,25),NC(8),IYN(2),ILC(2),IBCD(4),
          & IOVRQ(5,5),KXP(5),IWAIT,IFAERR(10),NPASS,KESC,IBL,IAUTR,
          & IAUTF,IBOVF,IMSK,IOFLG(5),INZERR(10)
      C
      C  :::  IOFLG = IVALB,SALARM,ISYSK,IOVRB,ITHE  :::
      C
            INTEGER*2 LANT11(40),LANT21(40),LANT12(40),LANT22(40),
          & LANT13(40),LANT23(40),LANT14(40),LANT24(40)
            INTEGER*2 CANT1(31),CANT2(31),CANT3(31),CANT4(31)
            INTEGER*2 IPLZ,IPOLZ(4),IPSD(2,512),IGTBL(80,4),IGTBC(31,4)
            INTEGER*2 ICLC(2),NPZN,IBND,ICNT,NFEL(8),IFDL(8),IDPT(8),INZ
      C
            CHARACTER*5 CIOVRQ(5),CFATAL(10)
            CHARACTER*2 CIYN,CILC,CIPOLZ(4),CCLC(2)
            CHARACTER*10 CFAERR(4)
      C   :::   FATAL,NERDAS,BUFFER,CALIBRATION   ::::
            CHARACTER*30 CRESP
            CHARACTER*60 CIOBUF,CNERD
      C
            EQUIVALENCE (CIOBUF,IOBUF),(CNERD,INERD),(INERD,IRESP),
          & (CRESP,IRESP),(CIYN,IYN),(CILC,ILC),(IPLZ,IRESP),(CIPOLZ,IPOLZ),
          & (CIOVRQ,IOVRQ),(CFAERR(1),IFAERR),(CFATAL,IFATAL),(CCLC,ICLC),
          & (CFAERR(3),IBFLW),(CFAERR(4),ICALW),(CFAERR(2),INZERR)
      C
            EQUIVALENCE (IGTBC(1,1),CANT1(1)),(IGTBC(1,2),CANT2(1)),
          & (IGTBC(1,3),CANT3(1)),(IGTBC(1,4),CANT4(1))
      C
            EQUIVALENCE (IGTBL(1,1),LANT11(1)),(IGTBL(41,1),LANT21(1)),
          & (IGTBL(1,2),LANT12(1)),(IGTBL(41,2),LANT22(1)),(IGTBL(1,3),LANT13(1)),
          & (IGTBL(41,3),LANT23(1)),(IGTBL(1,4),LANT14(1)),(IGTBL(41,4),LANT24(1))
      C
      C  :::   PARM = ALT,DRF,ROL,PCH,VEL   :::
      C
            COMMON XLMDA,DTHETA,XDELF,XSYSK,FCAL,BMWID,FNOIZ,
          & FPI3L,DLIM,DFALT,THETA,CIOVRQ,CIYN,CILC,CIPOLZ,KXP,IMSK,
          & NC,IGTBC,IGTBL,CFATAL,CFAERR,CCLC
      C
            COMMON/GG/CL(6),CC(7,2),CST(9)
            COMMON/A/IEOC,KESC
      C
            SAVE/A/
      C ::: BANDWIDTH RELATED CONSTANTS :::
            DATA BMWID/7.943,2.50/,FNOIZ/2100.,3580./,FPI3L/47.522,56.974/
      C :::  CONSTANT RESOLUTION ANGLE = 3.1 DEG FOR L-BND, 2.5 DEG FOR C-BND
      C        THIS GIVES 50 METER AND 40 METER CELLS WITH INTEGRATION
      C
            DATA XLMDA/0.18737,0.06311/,DTHETA/3.105,2.50/,XDELF/8.94531,20.63/
            DATA XSYSK/-118.4,-128.4,-117.4,-127.9,
          &            -119.0,-129.0,-118.0,-128.5/
      C
      C ::: CALIB, LIMITS, AND DEFAULT VALUES ::::
            DATA FCAL/1900., 2930., 3380./,
          & DLIM/304.8,-0.1745,-0.1745,-0.1745,51.4,
          &      609.6, 0.1745, 0.1745, 0.1745,102.8/
            DATA DFALT/457.2,0.0,0.0,0.0,77.1/
            DATA CIOVRQ/'ALT  ','DRIFT','ROLL ','PITCH','VEL  '/
```

```
C
C ::: VIEWING ANGLES (5,10,15,20,25,30,40,50) IN RADIANS
          DATA THETA/0.0873,0.1745,0.2618,0.3491,
     &             0.4363,0.5236,0.6981,0.8727/
C
          DATA CIYN/'YN'/,CILC/'LC'/,CIPOLZ/'VV','VH','HH','HV'/,
     &    KXP/1,2,4,8,16/,IMSK/#0FEH/,
     &    NC/5,10,11,13,14,20,30,40/
C
C
C ::: ANTENNA GAIN TABLE FOR 1.6GHZ :::, EQUIVALENCED TO IGTBL  :::
CC    VALUES ARE ORDERED SETS,  80 BY 4 MATRIX, -70 DEG TO +10 DEG EACH
C
C     *** 1.6VV :::
          DATA LANT11/147,152,154,155,157,161,164,169,174,177,
     &                179,183,187,191,194,197,199,203,206,211,
     &                216,218,219,219,219,222,224,226,227,228,
     &                229,227,226,227,229,227,224,223,222,221/
         DATA LANT21/219,217,214,214,214,213,210,210,209,208,
     &                207,211,214,214,214,216,217,219,221,221,
     &                222,222,222,222,221,221,219,217,214,213,
     &                212,211,209,208,207,204,201,199,197,194/
 C    *** 1.6VH :::
         DATA LANT12/214,218,222,224,227,229,232,236,239,240,
     &                241,243,246,247,249,250,251,255,259,260,
     &                261,261,262,262,262,263,264,263,262,262,
     &                262,264,256,256,256,251,246,244,242,249/
         DATA LANT22/236,233,229,226,222,219,216,213,209,215,
     &                201,201,201,199,197,195,194,195,197,198,
     &                199,200,201,205,209,209,209,211,214,216,
     &                217,219,222,222,222,222,222,221,219,216/
 C    *** 1.6HH :::
         DATA LANT13/231,234,237,239,242,243,244,244,244,244,
     &                244,245,246,246,246,246,246,248,249,248,
     &                246,245,244,244,244,244,244,242,239,238,
     &                237,234,231,230,229,226,224,222,219,217/
         DATA LANT23/214,211,209,206,204,202,199,195,191,190,
     &                189,188,186,185,184,184,184,184,184,186,
     &                189,189,189,193,197,197,197,197,197,197,
     &                197,197,197,193,189,188,187,184,181,179/
C
C    *** 1.6HV  ::::
         DATA LANT14/164,168,172,173,174,175,177,179,182,183,
     &                184,185,187,191,194,195,196,197,199,200,
     &                201,201,202,203,204,204,204,204,204,204,
     &                204,205,206,205,204,203,202,202,201,201/
         DATA LANT24/202,201,199,199,199,199,199,196,194,194,
     &                194,193,192,193,194,194,194,197,199,200,
     &                202,203,204,205,207,207,207,206,204,203,
     &                202,200,197,193,189,186,184,180,176,175/
C
C   ***  4.75GHZ  ANTENNA GAIN  ::, EQUIVALENCED TO IGTBC  ::::
C        ORDERED SET, 31 BY 4, 0 DEG TO 60 DEG
C
C     ::: 4.75VV  ::
          DATA CANT1/300,310,320,330,340,350,360,365,370,375,
     &               380,385,380,370,360,370,380,380,380,390,
     &               400,400,390,380,370,360,350,330,310,290,270/
 C    ::: 4.75VH   ::
          DATA CANT2/300,318,336,354,372,390,397,404,411,418,
     &               420,425,425,420,420,420,420,420,420,420,
     &               420,418,411,404,390,380,370,360,350,330,310/
 C    ::: 4.75HH   ::
          DATA CANT3/330,340,350,360,370,380,390,400,410,415,
     &               420,423,427,431,433,435,437,435,435,430,
     &               425,420,415,410,400,390,380,370,360,350,340/
 C    ::: 4.75HV   ::
          DATA CANT4/315,322,330,345,360,385,395,400,395,405,
     &               410,410,410,410,410,410,410,410,405,405,
     &               390,405,395,400,395,385,360,345,330,322,315/
 C
 C
          DATA CFATAL/'W0020','W0430','EF600','EF710','W0790',
      &            'W0815','W0850','W0864','W0868','UNDEF'/
C
        DATA CFAERR/'FATAL ERR*','**NERD ERR','**BUFF OVR','***CAL LOW'/
C
        DATA CCLC/' L',' C'/,CST/1.25,2.0,57.3,10.0,40.0,0.5,573.,0.3048,0.514/
C
        DATA CL/7.71094,-21.6914,14.941,1.11182,-0.0186787,1000./
        DATA CC/5.4637,9.61506,-15.2809,6.90396,-1.05396,3.2055,-0.305786,
      &        18.5575,-16.5981,8.64097,-3.44443,0.653213,-0.25549,0.001/
C
C  ********************INTERCOM****************************
C
C
C  ***   INITIALIZE I/O BOARD FOR CRT/KEY
        CALL IUSRT
C  !!!   INITIALIZE BI-PHASE-L I/O BOARD, CZT BOARD, AND INTERRUPT CONTROLLER
C
        CALL INIPIO
        CALL INICZT(IPSD)
        CALL INI259
        CALL LDJMPS
C
C  ***   SEND OUT SIGN-ON MESSAGE
    5   CALL CRLF
        IEFLG=1
        WRITE(CIOBUF,21,ERR=7000)
   21   FORMAT(10X,'NASA L/C-BAND PROCESSOR',17X)
        CALL MSGOUT(NC(8),IOBUF)
        CALL CRLF
C
C  ***   INITIALIZE FLAG SET ****************
        INZ=1
C
C  *******     SET OUTPUT BUFFER LINE LIMIT     **************
        IBL=70
C  ***   ***   ***   ***   ***   RE-CYCLE LOOP ENTRY ***   ***
C
   40   CONTINUE
        CALL IBELL
        CALL CRLF
        NPASS=1
        KESC=1
C !!! SET STARTING POINTERS INTO OUTPUT BUFFER !!!
C
        MX=IBL-10
        LT=MOD(MX,IBL)+1
C
C  *************************   PRE-LOAD OUTPUT BUFFER W/099H   *****
        ICNT=25
        CALL IBFILL(ICNT,IOUT(1,11))
C
C  *** *** *** *** *** *** ***   SET UP OPTIONS   ***   ***
        CALL CRLF
        GO TO (115,85),INZ
   85   CONTINUE
        CRESP='      NEW SET-UP(Y/N)?'
        CALL IBELL
        CALL MSGOUT(NC(7),IRESP)
        CALL KEYBRD(NC(1),IRESP)
        IF(IRESP(1).EQ.#1BH) GO TO 5
        IF(IRESP(1).EQ.IYN(2))GO TO 740
C
C  **********************************SET BAND IDENTIFIER********
  115   CONTINUE
        IBND=1
        CRESP='      TYPE OF SCAT(L/C)?'
        CALL MSGOUT(NC(7),IRESP)
        CALL KEYBRD(NC(1),IRESP)
        IF(IRESP(1).EQ.ILC(2))IBND=2
C
C  ********************************SET BAND RELATED VARIABLES******
        BMW=BMWID(IBND)/CST(3)
        SLMDA=XLMDA(IBND)
      DELF=XDELF(IBND)
      NZL=IFIX(FNOIZ(IBND)/DELF)-6/IBND+1
      NZE=(6/IBND)*2
C
C   ******************************  SET POLARIZATION IDENTIFIER   ******
 160  NPZN=0
      CRESP='      POLARITY(VV,VH,HH,HV)?'
      CALL  MSGOUT(NC(7),IRESP)
      CALL  KEYBRD(NC(1),IRESP)
      DO 180 L=1,4
      IF(IPLZ.EQ.IPOLZ(L))NPZN=L
 180  CONTINUE
      IF(NPZN.EQ.0)GO TO 160
C
C   ********************************   SET POLARIZATION VARIABLES ******
      RCAL=FCAL(IBND)
      GO TO (200,195),IBND
 195  GO TO (196,196,200,200),NPZN
 196  RCAL=FCAL(3)
C
C   ********************************   ANGULAR RESOLUTION OPTION   ******
 200  IFCAL=512-IFIX(RCAL/DELF)-6/IBND+1
 203  CRESP='      ANG RESOL O/RIDE(Y/N)?'
      CALL  MSGOUT(NC(7),IRESP)
      CALL  KEYBRD(NC(1),IRESP)
      IOFLG(5)=1
      IF(IRESP(1).EQ.IYN(2)) GO TO 255
C
C   ********************************   READ OVER-RIDE RESOLUTION   ******
      IOFLG(5)=2
      CALL  GETVLU(CRESP,IRESP,NC(2),NC(6),IERR,DTHEI)
      IF(IERR.NE.0) GO TO 203
      GO TO 260
 255  DTHEI=DTHETA(IBND)
C !!! SET VALUE OF DTHETA/2. TO RADIANS  !!!
 260  DTHER=(DTHEI/CST(3))/CST(2)
C
C   *****************************  SYSTEM CONSTANT OPTION   **********
      IOFLG(3)=0
 305  CRESP='      SYS CONST O/RIDE(Y/N)?'
      CALL  MSGOUT(NC(7),IRESP)
      CALL  KEYBRD(NC(1),IRESP)
      IF(IRESP(1).EQ.IYN(2)) GO TO 380
      IOFLG(3)=1
C
C   ***************************   RESET SYS CONSTANT   ***************
      CALL  GETVLU(CRESP,IRESP,NC(2),NC(6),IERR,SYSK)
      IF(IERR.NE.0) GO TO 305
      IF(SYSK.GT.0.) SYSK=-SYSK
      GO TO 385
 380  SYSK=XSYSK(NPZN,IBND)
C
C   ***************************   NERDAS VALUE OVER-RIDE OPTION   ******
 385  CONTINUE
      CRESP='      ACFT DATA O/RIDES(Y/N)?'
      CALL  MSGOUT(NC(7),IRESP)
      CALL  KEYBRD(NC(1),IRESP)
      IOFLG(4)=0
      DO 415 J=1,5
      IOVER(J)=0
 415  CONTINUE
      IF(IRESP(1).EQ.IYN(2)) GO TO 500
C
C   *************************   AIRCRAFT DATA OVER-RIDE ENTRIES   ******
      DO 475 J=1,5
      IEFLG=2
      WRITE(CRESP,430,ERR=7000) CIOVRQ(J)
 430  FORMAT(5X,'O/RIDING ',1A5,' (Y/N)?',4X)
      CALL  MSGOUT(NC(7),IRESP)
      CALL  KEYBRD(NC(1),IRESP)
      IF(IRESP(1).EQ.IYN(2)) GO TO 473
 460  CALL  GETVLU(CRESP,IRESP,NC(2),NC(6),IERR,ACOVR(J))
```

```
      IF(IERR.NE.0) GO TO 460
      IOVER(J)=1
  473 IOFLG(4)=IOFLG(4)+IOVER(J)*KXP(J)
  475 CONTINUE
C
C    ********************* INITIALIZE PARM VALUES    ***************
      DO 490 J=1,5
      IF(IOVER(J).EQ.0)GO TO 490
      GO TO (481,482,482,482,483),J
  481 PARM(J)=ACOVR(J)*CST(8)
      GO TO 490
  482 PARM(J)=ACOVR(J)/CST(3)
      GO TO 490
  483 PARM(J)=ACOVR(J)*CST(9)
  490 CONTINUE
C
C   *********************    START/STOP TIME OPTIONS    *************
  500 GO TO (545,520), INZ
  520 CONTINUE
      CRESP='      CHG START TIME(Y/N)?'
      CALL MSGOUT(NC(7),IRESP)
      CALL KEYBRD(NC(1),IRESP)
      IF(IRESP(1).EQ.IYN(2)) GO TO 625
      GO TO 570
C
C   *************************   START TIME OPTION    *****************
  545 CONTINUE
      CRESP='      START TIME CMD(Y/N)?'
      CALL MSGOUT(NC(7),IRESP)
      CALL KEYBRD(NC(1),IRESP)
      IF(IRESP(1).EQ.IYN(2)) GO TO 620
C
C   ****************************      SET START TIME      **************
  570 CONTINUE
      CRESP='      SET START TIME(HHMMSS)'
      CALL MSGOUT(NC(7),IRESP)
      CALL KEYBRD(NC(2),IRESP)
      CALL ASCDV(NC(2),IRESP)
      IEFLG=3
      READ(CRESP,600,ERR=570,END=7000)(START(J),J=1,3)
  600 FORMAT(3F2.0)
      IAUTR=2
      T0=START(1)*3600.+START(2)*60.+START(3)
      GO TO 625
  620 IAUTR=1
C
C   *****************************    STOP TIME CHANGE OPTIONS    ******
  625 GO TO (655,630),INZ
  630 CONTINUE
      CRESP='      CHG STOP TIME(Y/N)?'
      CALL MSGOUT(NC(7),IRESP)
      CALL KEYBRD(NC(1),IRESP)
      IF(IRESP(1).EQ.IYN(2)) GO TO 740
      GO TO 680
C
C   ****************************    STOP TIME OPTION · ******************
  655 CONTINUE
      CRESP='      STOP TIME CMD(Y/N)?'
      CALL MSGOUT(NC(7),IRESP)
      CALL KEYBRD(NC(1),IRESP)
      IF(IRESP(1).EQ.IYN(2)) GO TO 730
C
C   ****************************    SET NUMBER OF SECONDS TO RUN    ******
  680 CONTINUE
      CRESP='      SET RUN TIME,SECS(F5.0)'
      CALL MSGOUT(NC(7),IRESP)
      CALL KEYBRD(NC(2),IRESP)
      CALL ASCDV(NC(1),IRESP)
      IEFLG=4
      READ(CRESP,710,ERR=680,END=7000)DELT
  710 FORMAT(F5.0)
      IAUTP=2
```

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OF POOR QUALITY

```
            GO TO 740
  730       IAUTP=1
  740       CALL CRLF
            CRESP='      DISPLAY SET-UP(Y/N)?'
            CALL MSGOUT(NC(7),IRESP)
            CALL KEYBRD(NC(1),IRESP)
            IF(IRESP(1).EQ.IYN(2)) GO TO 870
C
            CALL CRLF
            IEFLG=5
            WRITE(CRESP,790,ERR=7000)CCLC(IBND),CIPOLZ(NPZN),SLMDA
  790       FORMAT(4X,1A2,'-BAND(',1A2,')',  W/LN=',F6.4,1X)
            CALL MSGOUT(NC(7),IRESP)
            CALL CRLF
            IEFLG=6
            WRITE(CRESP,815,ERR=7000)DTHEI,SYSK
  815       FORMAT(5X,'RESOL=',F6.3,1X,'SYSK=',F6.1,1X)
            CALL MSGOUT(NC(7),IRESP)
            IEFLG=7
            DO 860 J=1,5
            IF(IOVER(J).EQ.0) GO TO 860
            CALL CRLF
            WRITE(CRESP,850,ERR=7000)CIOVRQ(J),ACOVR(J)
  850       FORMAT(5X,1A5,'=',F9.3,10X)
            CALL MSGOUT(NC(7),IRESP)
  860       CONTINUE
C
            GO TO (865,862),IAUTR
  862       IEFLG=8
            WRITE(CRESP,864,ERR=7000)(START(I),I=1,3)
  864       FORMAT(5X,'START TIME=',3(F3.0),5X)
            CALL CRLF
            CALL MSGOUT(NC(7),IRESP)
C
  865       GO TO (870,866),IAUTP
  866       IEFLG=9
            WRITE(CRESP,868,ERR=7000)DELT
  868       FORMAT(5X,'RUN TIME=',F7.1,9X)
            CALL CRLF
            CALL MSGOUT(NC(7),IRESP)
C   ****************** RE-START OPTION  ***************
C
  870       CALL CRLF
            CRESP='      READY TO RUN(Y/N)?'
            CALL MSGOUT(NC(7),IRESP)
            CALL KEYBRD(NC(1),IRESP)
            IF(IRESP(1).EQ.IYN(2)) GO TO 40
C
C   ****************** INITIALIZATION COMPLETED   ****************
C
C                BEGIN RUN MODULE
C
            INZ=2
C
C   ***************      SIGMA1      ***********************************
C
$INCLUDE(:F1:SIGMA1.SRC)
   =  C         SIGMA1 MODULE
   =  C
   =  C  ***********************************************************
   =  C
   =  C
   =            TC=1.0
   =            NZPAS=0
   =  C :.::    SET NERDAS NIB COUNT
   =            J=110
   =  C  *************************************RE-ENTRY POINT FROM SIGMA2   *
   =  C
   =  C  ****************************CHECK KEYBOARD FOR PENDING CHARACTER
   =  C
   =    915   CALL KEYCHK
   =  C  ****************************** LOOP BACK FOR TIME SEARCH ******
```

```
C
  925   CONTINUE
C
C  ****************************************READ IN A NERDAS FRAME****
        CALL NERD(J,IOUT(1,LT))
C
C  *************************DECODE A/C DATA; T1,ALT,DRF,ROL,PCH,VEL
C   !!!   NOTE!!!   PARM(1),. . . ,(5) = ALT,DRF,ROL,PCH,VEL   !!!!
C
        CALL IBELL
        CALL UNPACK(IOUT(1,LT),INERD)
        CALL DECODA(IOVER,INERD,T1,PARM)
        GO TO (930,940),IAUTR
  930   GO TO (935,945),NPASS
  935   T0=T1
  940   IF(T1.LT.T0) GO TO 925
  945   CALL AMDSUB(TDEL,T1,T0)
        IF(NZPAS.GE.10) GO TO 950
        CALL VALID(DLIM,DFALT,IOVER,IOFLG(1),PARM)
        NZPAS=NZPAS+1
        GO TO 955
  950   CALL RUNLMT(PREV,IOVER,PARM)
  955   DO 960 K=1,5
        PREV(K)=PARM(K)
  960   CONTINUE
C   !!!     !!!!    CHECK VALIDITY OF NERDAS DATA   !!!!
        IF(IOFLG(1).EQ.0) GO TO 965
        IF(NZPAS.GE.10) GO TO 965
C   *******************   SEND OUT NERDAS WARNING MESSAGE   ****
C
        CALL CRLF
        CALL IBELL
        CALL MSGOUT(NC(2),INZERR)
C  ********************** SKIP TIME CHECK WHEN NERDAS IN ERROR  *****
        GO TO 977
  965   GO TO (977,975), IAUTP
  975   IF(DELT.LE.TDEL) GO TO 7777
  977   GO TC (1000,7777),KESC
 1000   DO 1005 I=1,8
C   **********   EVAL CELL SIZES (DTHER=DTHETA/2. IN RAD)
        CALL AMDADD(SUM,THETA(I),DTHER)
        CALL AMDSUB(DIFF,THETA(I),DTHER)
        CALL CCELL(CELL(I),DIFF,SUM,PARM(1))
 1005   CONTINUE
C
C   **************************  COMPUTE INTEGRATION TIME  ********
        CALL AMDIV(TI,CELL(1),PARM(5))
C  ********************/****** SET INTERRUPT MASK FOR LEVEL 0 *****
C
 1030   CALL MSKSET(IMSK)
C
C  *************************** START INTEGRATION ***********
        CALL INTGT(ICNT,TI,DELF)
        CALL CZT(ICNT)
        IEOC=1
        IBOVF=1
        IWAIT=1
        IOFLG(2)=0
C  !!!   SET ICNT = NBR OF CELLS IN VIEW   !!!
        CALL CELCNT(ICNT,PARM(5),TC,PARM(1),THETA(8))
        IF(ICNT.LE.IBL)GO TO 1050
        IBOVF=2
        ICNT=IBL
        IOFLG(2)=IOFLG(2).OR.KXP(3)
        GO TO 1060
 1050   IOFLG(2)=IOFLG(2).AND.NC(3)
 1060   GO TO (1100,1065),IBOVF
 1065   CALL CRLF
        CALL MSGOUT(NC(2),IBFLW)
 1100   CONTINUE
C  *******  SET VARIABLES PC & PN FOR POINTER EVALUATIONS  !!!!!
C
```

```
            CALL  PCPN(PN,TI,PC,TC,PARM(1),PARM(5))
      C
      C   *************************  COMPUTE A/C RELATED VALUES   ****
      C
            AROL=ABS(PARM(3))
      C   ***********************  COMPUTE ANGLE RELATED VALUES  ********
      C
            DO 1305 I=1,8
            ANGL=-THETA(I)
            IF(AROL.GT.THETA(I))ANGL=-AROL
            CALL  GXT(XT,PARM(3),ANGL,PARM(1))
            CALL  GXI(XI,XT,PARM(1),PARM(3),PARM(2))
            CALL  GYI(YI,XT,PARM(1),PARM(3),PARM(2))
            CALL  AMDIV(XT,CELL(1),CST(2))
            IF(XI.LT.XT)XI=XT
      C
      C   *********  COMPUTE DOPPLER ANGLE AND NBR OF FILTER ELEMENTS  ****
      C
            CALL  CNFILT(NFEL(I),DELF,BNDW,CELL(I),FDOP,ANGL,YI,XI,XT,SLMDA,
           &  PARM(5),PARM(1))
            IF(NFEL(I).LT.1)NFEL(I)=1
      C
      C   ********************   EVALUATE TRUE BANDWIDTH  ********
      C
            CALL  CBNDW(BNDW,NFEL(I),DELF)
            IF(MOD(NFEL(I),2).EQ.0) GO TO 1200
      C !!! ODD NBR OF ELEMENTS  !!!
            L=2
            CALL  FDLOD(IFDL(I),NFEL(I),L,FDOP,DELF)
            GO TO 1210
      C  !!! EVEN NBR OF ELEMENTS  !!!
       1200   L=3
            CALL  FDLEV(IFDL(I),NFEL(I),L,FDOP,DELF)
       1210   CONTINUE
            IF(IFDL(I).LE.0)IFDL(I)=1
      C
      C   ******  COMPUTE TRUE DOPPLER ANGLE AND LOAD POINTERS   ******
      C
            CALL  AMDIV(ANGL,FDOP,XT)
            IF(ANGL.GT.1.)ANGL=1.
            CALL  CLNPT(IBPT(I),LT,PC,PN,XT,YI,ANGL,PARM(1))
            IF(IBPT(I).LE.0)IBPT(I)=IBL+IBPT(I)
      C   ******************   ESTABLISH OUTPUT LOOK ANGLE   ************
      C
            ANGTL=THETA(I)
            IF(ANGTL.LT.AROL)ANGTL=AROL
            CALL  AMDMUL(ANGT(I),ANGTL,CST(3))
      C
      C
      C   **************************   ESTABLISH ANTENNA VIEWING ANGLE   ****
            ANGL=-ANGTL
      C
            SIGMA(I)=0.0
       1305   CONTINUE
      C
       1310   IF(IEOC.NE.1) GO TO 1650
            IWAIT=2
            GO TO 1310
      C
      C   ******************  END OF SIGMA1 MODULE   ****************
      C
      C   *****************     SIGMA2     *******************************
      C
      $INCLUDE(:F1:SIGMA2.SRC)
      C
      C*********************** SIGMA2 MODULE ***********************
      C
      C************************************************************
      C      ENTRY CONDITIONAL ON IEOC FLAG SET BY CZT-BOARD INTERRUPT
      C        CZTINT ROUTINE WILL HAVE MASKED ALL INTERRUPTS
      C
       1650   IF(IWAIT.EQ.1)GO TO 1657
```

```
C    SET ALARM WORD BIT FOR TIME
          IOFLG(2)=IOFLG(2).OR.KXP(2)
          GO TO 1660
C*********************************************************************
 1657     IOFLG(2)=IOFLG(2).AND.NC(4)
C   READ IN CZT-BOARD DATA VIA DMA
 1660     CALL CZTR
C
C   EVALUATE NOISE POWER
          CALL I32SUM(PN,IPSD(1,NZL),NZE)
C   EVALUATE CALIBRATION POWER
          CALL I32SUM(PC,IPSD(1,IFCAL),NZE)
C   CHECK FOR CALIB TONE >> NOISE
          CALL AMDSUB(XT,PC,PN)
          IF(XT.GE.CC(1,1))GO TO 1689
          IOFLG(2)=IOFLG(2).OR.KXP(1)
          CALL  CRLF
          CALL MSGOUT(NC(2),ICALW)
          GO TO 1690
 1689     IOFLG(2)=IOFLG(2).AND.NC(5)
C   PERFORM POWER SUMS OVER EACH BAND
C         AND CALCULATE SIGMA VALUES
 1690     DO 1700 I=1,8
          CALL I32SUM(PR,IPSD(1,IFBL(I)),NFEL(I))
          CALL AMDSUB(XT,PR,PC)
          CALL AMDADD(SIGMA(I),SIGMA(I),XT)
 1700     CONTINUE
C
C********** MOVE ANGLES,SIGMA,NOISE & CAL-PWR,& FLAGS TO OUTPUT  ********
          ICNT=1
          DO 1800 K=1,8
          I=55+(K-1)*2
          CALL MFPNUM(ANGT(K),I,LT,IOUT,IBCD,ICNT)
 1800     CONTINUE
          ICNT=8
          I=71
 1900     CALL MFPNUM(SIGMA,I,IBPT,IOUT,IBCD,ICNT)
          I=87
          ICNT=1
          CALL MFPNUM(PC,I,LT,IOUT,IBCD,ICNT)
          I=89
          CALL MFPNUM(PN,I,LT,IOUT,IBCD,ICNT)
          I=91
          CALL MFLAG(I,IOFLG,IOUT(1,LT),IBND,NPZN)
C*********   SET OUTPUT POINTER   **************
          ICNT=LT-IBL/2
          IF(ICNT.LE.0)ICNT=ICNT+IBL
C
C   !!!!!!!!! REPLACE SYNC BYTE IN OUTPUT LINE !!!!!!!!!
          IOUT(1,ICNT)=#0FBH
          IOUT(2,ICNT)=#0F1H
C
C   !!!!!!!!!!!!   WRITE TO BI-PHASE-L  !!!!!!!!!!!
C
          CALL KBPHAL(IOUT(1,ICNT))
C
C*************  SET LOOP CONTROLS  ****************
          NPASS=2
C  !! SET LOAD POINTER FOR NEXT LINE  !!
          MX=MX+1
          IF(MX.LE.0)MX=LT
          LT=MOD(MX,IBL)+1
C  !!! LOOP BACK TO NEXT FRAME !!!
C
          GO TO 915
C
C   ******************   READ - WRITE ERROR RECOVERY   ***************
C
 7000     CALL CRLF
          CALL MSGOUT(NC(2),IFAERR)
          CALL MSGOUT(NC(1),IFATAL(1,IEFLG))
          CALL CRLF
```

```
                CALL DWAIT
      C
      C
      C     ******************     RUN MODULE TERMINATION    ********
      C
       7777     ICNT=LT-IBL/2
        777     K=ICNT
                IF(ICNT.LE.0)K=ICNT+IBL
                CALL KBPHAL(IOUT(1,K))
                ICNT=ICNT+1
                IF(ICNT.GE.LT)GO TO 40
                GO TO 777
      C
                END
```

```
CROSS-REFERENCE LISTING
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  DEFN  ADDR  SIZE  NAME, ATTRIBUTES, AND REFERENCES
  ----  ----  ----  --------------------------------

              1248                COMMON-BLOCK
                                   16   17   18

   272 0E28H        1000          LABEL
                                  271  272

   276 0E7BH        1005          LABEL
                                  272  276

   278 0E92H        1030          LABEL
                                  278

   291 0F01H        1050          LABEL
                                  286  291

   292 0F0BH        1060          LABEL
                                  290  292

   293 0F1AH        1065          LABEL
                                  292  293

   295 0F26H        1100          LABEL
                                  292  295

    76 0352H        115           LABEL
                                   68   76

   313 10ABH        1200          LABEL
                                  309  313

   315 10D0H        1210          LABEL
                                  312  315

   326 11BAH        1305          LABEL
                                  298  326

   327 11C4H        1310          LABEL
                                  327  329

    87 03ECH        160           LABEL
                                   87   94

   331 11DBH        1650          LABEL
                                  327  331

   334 11FAH        1657          LABEL
                                  331  334

   335 1204H        1660          LABEL
                                  333  335

   344 126BH        1689          LABEL
                                  339  344

   345 1275H        1690          LABEL
                                  343  345

   349 12D1H        1700          LABEL
                                  345  349

    93 0440H        180           LABEL
                                   91   93

   354 131BH        1800          LABEL
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                                    351  354

   357 1331H          1900          LABEL
                                    357

    97 0474H          195           LABEL
                                     96   97

    98 0484H          196           LABEL
                                     97   98

    99 048DH          200           LABEL
                                     96   97   99

   100 04B5H          203           LABEL
                                    100  107

    53 017AH          21            LABEL
                                     52   53

   109 0520H          255           LABEL
                                    104  109

   110 052FH          260           LABEL
                                    108  110

   112 054CH          305           LABEL
                                    112  118

   121 05CDH          380           LABEL
                                    115  121

   122 05E3H          385           LABEL
                                    120  122

    58 02CEH          40            LABEL
                                     58  238  385

   129 0628H          415           LABEL
                                    127  129

   134 019DH          430           LABEL
                                    133  134

   138 06BDH          460           LABEL
                                    138  139

   141 06F9H          473           LABEL
                                    137  141

   142 0715H          475           LABEL
                                    131  142

   146 075AH          481           LABEL
                                    145  146

   148 077CH          482           LABEL
                                    145  148

   150 079EH          483           LABEL
                                    145  150

   151 07BDH          490           LABEL
                                    143  144  147  149  151

    50 027BH          5             LABEL
                                     50   74

   152 07C7H          500           LABEL
                                    130  152

   153 07D3H          520           LABEL
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                                 152  153

   159 0808H        545          LABEL
                                 152  159

   164 083AH        570          LABEL
                                 158  164  170

   171 01BEH        600          LABEL
                                 170  171

   175 090EH        620          LABEL
                                 163  175

   176 0913H        625          LABEL
                                 157  174  176

   177 091FH        630          LABEL
                                 176  177

   183 0954H        655          LAPEL
                                 176  183

   188 0986H        680          LABEL
                                 182  188  194

   375 144AH        7000         LABEL
                                  52  133  170  194  206  211  218  224  230  375

   195 01C5H        710          LABEL
                                 194  195

   198 0A04H        730          LABEL
                                 187  198

   199 0A09H        740          LABEL
                                  75  181  197  199

   381 1488H        777          LABEL
                                 381  386

   380 146EH        7777         LABEL
                                 270  271  380

   207 01CBH        790          LABEL
                                 206  207

   212 01F4H        815          LABEL
                                 211  212

    69 0312H        85           LABEL
                                  68   69

   219 0219H        850          LABEL
                                 218  219

   221 0B9AH        860          LABEL
                                 215  216  221

   223 0BB3H        862          LABEL
                                 222  223

   225 022EH        864          LABEL
                                 224  225

   228 0C25H        865          LABEL
                                 222  228

   229 0C34H        866          LABEL
                                 228  229

   231 024BH        868          LABEL
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                                      230  231

     234 0C82H        870             LABEL
                                      203  228  234

     244 0CD2H        915             LABEL
                                      244  374

     245 0CD5H        925             LABEL
                                      245  253

     251 0D23H        930             LABEL
                                      250  251

     252 0D32H        935             LABEL
                                      251  252

     253 0D3BH        940             LABEL
                                      250  253

     254 0D4DH        945             LABEL
                                      251  254

     259 0D88H        950             LABEL
                                      255  259

     260 0D95H        955             LABEL
                                      258  260

     262 0DBBH        960             LABEL
                                      260  262

     269 0DF8H        965             LABEL
                                      263  264  269

     270 0E07H        975             LABEL
                                      269  270

     271 0E19H        977             LABEL
                                      268  269  271

         2C8EH    18  @IOPB           INTEGER*2 DIMENSIONED
                                       52

                   3  A               COMMON-BLOCK
                                       18   19

                      ABS             INTRINSIC
                                      297

         0060H    20  ACOVR           REAL*4 DIMENSIONED
                                        2  138  146  148  150  218

                      AMDADD          EXTERNAL SUBROUTINE
                                      273  348

                      AMDIV           EXTERNAL SUBROUTINE
                                      277  304  317

                      AMDMUL          EXTERNAL SUBROUTINE
                                      323

                      AMDSUB          EXTERNAL SUBROUTINE
                                      254  274  338  347

         2CFEH     4  ANGL            REAL*4
                                      299  300  301  306  317  318  319  324

         0040H    32  ANGT            REAL*4 DIMENSIONED
                                        2  323  353

         2D16H     4  ANGTL           REAL*4
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                                      321   322   323   324
          2CFAH      4   AROL         REAL*4
                                      297   300   322
                         ASCDV        EXTERNAL SUBROUTINE
                                      168   192
          2CA4H      4   BMW          REAL*4
                                       82
          0044H      8   BMWID        REAL*4 DIMENSIONED COMMON
                                        2    16    20    82
          2D0EH      4   BNDW         REAL*4
                                      306   308
          00EBH     62   CANT1        INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                        5    14    36
          0129H     62   CANT2        INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                        5    14    37
          0167H     62   CANT3        INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                        5    14    38
          01A5H     62   CANT4        INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                        5    14    39
                         CBNDW        EXTERNAL SUBROUTINE
                                      308
          0018H     56   CC           REAL*4 DIMENSIONED COMMON
                                       17    44   339
                         CCELL        EXTERNAL SUBROUTINE
                                      275
          04BDH      4   CCLC         CHARACTER*2 DIMENSIONED COMMON EQUIVALENCED
                                        9    13    16    42   206
                         CELCNT       EXTERNAL SUBROUTINE
                                      285
          0000H     32   CELL         REAL*4 DIMENSIONED
                                        2   275   277   304   306
          0495H     40   CFAERR       CHARACTER*10 DIMENSIONED COMMON EQUIVALENCED
                                       10    13    16    41
          0463H     50   CFATAL       CHARACTER*5 DIMENSIONED COMMON EQUIVALENCED
                                        8    13    16    40
          00D3H      2   CILC         CHARACTER*2 COMMON EQUIVALENCED
                                        9    13    16    27
          00C8H     60   CIOBUF       CHARACTER*60 EQUIVALENCED
                                       12    13    52
          00B8H     25   CIOVRQ       CHARACTER*5 DIMENSIONED COMMON EQUIVALENCED
                                        8    13    16    25   133   218
          00D5H      8   CIPOLZ       CHARACTER*2 DIMENSIONED COMMON EQUIVALENCED
                                        9    13    16    27   206
          00D1H      2   CIYN         CHARACTER*2 COMMON EQUIVALENCED
                                        9    13    16    27
          0000H     24   CL           REAL*4 DIMENSIONED COMMON
                                       17    43
                         CLNPT        EXTERNAL SUBROUTINE
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                                319
     0104H    60   CNERD        CHARACTER*60 EQUIVALENCED
                                 12    13
                   CNFILT       EXTERNAL SUBROUTINE
                                306
     0104H    30   CRESP        CHARACTER*30 EQUIVALENCED
                                 11    13    70    78    88   100   106   112   117   123   133
                                138   154   160   165   170   178   184   189   194   200   206
                                211   218   224   230   235
                   CRLF         EXTERNAL SUBROUTINE
                                 50    55    60    67   199   204   209   217   226   232   234
                                265   293   341   375   378
     0050H    36   CST          REAL*4 DIMENSIONED COMMON
                                 17    42    82   110   146   148   150   304   323
                   CZT          EXTERNAL SUBROUTINE
                                280
                   CZTR         EXTERNAL SUBROUTINE
                                335
                   DECODA       EXTERNAL SUBROUTINE
                                249
     2CACH     4   DELF         REAL*4
                                 84    85    99   279   306   308   311   314
     2CD0H     4   DELT         REAL*4
                                194   230   270
     0084H    20   DFALT        REAL*4 DIMENSIONED COMMON
                                  2    16    24   256
     2CEAH     4   DIFF         REAL*4
                                274   275
     005CH    40   DLIM         REAL*4 DIMENSIONED COMMON
                                  2    16    23   256
     2CBEH     4   DTHEI        REAL*4
                                106   109   110   211
     2CC2H     4   DTHER        REAL*4
                                110   273   274
     0008H     8   DTHETA       REAL*4 DIMENSIONED COMMON
                                  2    16    21   109
                   DWAIT        EXTERNAL SUBROUTINE
                                379
     0038H    12   FCAL         REAL*4 DIMENSIONED COMMON
                                  2    16    23    95    98
                   FDLEV        EXTERNAL SUBROUTINE
                                314
                   FDLOD        EXTERNAL SUBROUTINE
                                311
     2D12H     4   FDOP         REAL*4
                                306   311   314   317
     004CH     8   FNOIZ        REAL*4 DIMENSIONED COMMON
                                  2    16    20    85
     0054H     8   FPI3L        REAL*4 DIMENSIONED COMMON
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                                          2    16    20

                         GETVLU         EXTERNAL SUBROUTINE
                                        106   117   138

               116       GG             COMMON-BLOCK
                                         17

                         GXI            EXTERNAL SUBROUTINE
                                        302

                         GXT            EXTERNAL SUBROUTINE
                                        301

                         GYI            EXTERNAL SUBROUTINE
                                        303

         2CD4H       2   I              INTEGER*2
                                        224   272   273   274   275   298   299   300   306   307   308
                                        309   311   314   316   319   320   321   323   325   345   346
                                        348   352   353   356   357   358   360   361   362   363   364

                         I32SUM         EXTERNAL SUBROUTINE
                                        336   337   346

         244DH       1   IAUTP          INTEGER*1
                                          3   196   198   228   269

         244CH       1   IAUTR          INTEGER*1
                                          3   172   175   222   250

         2445H       4   IBCD           INTEGER*1 DIMENSIONED
                                          3   353   357   360   362

                         IBELL          EXTERNAL SUBROUTINE
                                         59    71   247   266

                         IBFILL         EXTERNAL SUBROUTINE
                                         66

         04A9H       2   IBFLW          INTEGER*2 COMMON EQUIVALENCED
                                         13   294

         244BH       1   IBL            INTEGER*1
                                          3    57    63    64   286   288   320   365   366   373   380
                                        382

         2C56H       2   IBND           INTEGER*2
                                          7    77    81    82    83    84    85    86    95    96    99
                                        109   121   206   364

         244EH       1   IBOVF          INTEGER*1
                                          3   282   287   292

         2C7AH      16   IBPT           INTEGER*2 DIMENSIONED
                                          7   319   320   357

         04B3H       2   ICALW          INTEGER*2 COMMON EQUIVALENCED
                                         13   342

         04BDH       4   ICLC           INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                          7    13

         2C58H       2   ICNT           INTEGER*2
                                          7    65    66   279   280   285   286   288   350   353   355
                                        357   359   360   362   365   366   367   368   369   380   381
                                        382   384   385

         2C8CH       2   IEFLG          INTEGER*2
                                         51   132   169   193   205   210   214   223   229   377

         0000H       2   IEOC           INTEGER*2 COMMON
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                                 18   281   327

        2CBCH      2  IERR      INTEGER*2
                                106   107   117   118   138   139

        0495H     10  IFAERR    INTEGER*1 DIMENSIONED COMMON EQUIVALENCED
                                  3    13   376

        0463H    125  IFATAL    INTEGER*1 DIMENSIONED COMMON EQUIVALENCED
                                  3    13   377

        2CBAH      2  IFCAL     INTEGER*2
                                 99   337

        2C6AH     16  IFDL      INTEGER*2 DIMENSIONED
                                  7   311   314   316   346

                      IFIX      INTRINSIC
                                 85    99

        00EBH    248  IGTBC     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                  6    14    16

        01E3H    640  IGTBL     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                  6    15    16

        00D3H      2  ILC       INTEGER*1 DIMENSIONED COMMON EQUIVALENCED
                                  3    13    81

        00E2H      1  IMSK      INTEGER*1 COMMON
                                  3    16    27   278

        0104H     60  INERD     INTEGER*1 DIMENSIONED EQUIVALENCED
                                  3    13   248   249

                      INI259    EXTERNAL SUBROUTINE
                                 48

                      INICZT    EXTERNAL SUBROUTINE
                                 47

                      INIPIO    EXTERNAL SUBROUTINE
                                 46

                      INTGT     EXTERNAL SUBROUTINE
                                279

        2C8AH      2  INZ       INTEGER*2
                                  7    56    68   152   176   239

        049FH     10  INZERR    INTEGER*1 DIMENSIONED COMMON EQUIVALENCED
                                  3    13   267

        00C8H     60  IOBUF     INTEGER*1 DIMENSIONED EQUIVALENCED
                                  3    13    54

        244FH      5  IOFLG     INTEGER*1 DIMENSIONED
                                  3   103   105   111   116   126   141   256   263   284   289
                                291   332   334   340   344   364

        0145H   8960  IOUT      INTEGER*1 DIMENSIONED
                                  3    66   246   248   353   357   360   362   364   367   368
                                369   383

        0140H      5  IOVER     INTEGER*1 DIMENSIONED
                                  3   128   140   141   144   216   249   256   259

        00B8H     25  IOVRQ     INTEGER*1 DIMENSIONED COMMON EQUIVALENCED
                                  3    13

        0104H      2  IPLZ      INTEGER*2 EQUIVALENCED
                                  6    13    92
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      00D5H     8  IPOLZ      INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                6   13   92

      2454H  2048  IPSD       INTEGER*2 DIMENSIONED
                                6   47  336  337  346

      0104H    30  IRESP      INTEGER*1 DIMENSIONED EQUIVALENCED
                                3   13   72   73   74   75   79   80   81   89   90
                              101  102  104  106  113  114  115  117  124  125  130
                              135  136  137  138  155  156  157  161  162  163  166
                              167  168  179  180  181  185  186  187  190  191  192
                              201  202  203  208  213  220  227  233  236  237  238

                   IUSRT      EXTERNAL SUBROUTINE
                               45

      2449H     1  IWAIT      INTEGER*1
                                3  283  328  331

      00D1H     2  IYN        INTEGER*1 DIMENSIONED COMMON EQUIVALENCED
                                3   13   75  104  115  130  137  157  163  181  187
                              203  238

      2CCAH     2  J          INTEGER*2
                              127  128  131  133  138  140  141  143  144  145  146
                              148  150  170  215  216  218  243  246

      2CE4H     2  K          INTEGER*2
                              260  261  351  352  353  381  382  383

                   KBPHAL     EXTERNAL SUBROUTINE
                              369  383

      0002H     1  KESC       INTEGER*1 COMMON
                                3   18   62  271

                   KEYBRD     EXTERNAL SUBROUTINE
                               73   80   90  102  114  125  136  156  162  167  180
                              186  191  202  237

                   KEYCHK     EXTERNAL SUBROUTINE
                              244

      00DDH     5  KXP        INTEGER*1 DIMENSIONED COMMON
                                3   16   27  141  289  332  340

      2CB4H     2  L          INTEGER*2
                               91   92  310  311  313  314

      01E3H    80  LANT11     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   28

      0283H    80  LANT12     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   30

      0323H    80  LANT13     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   32

      03C3H    80  LANT14     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   34

      0233H    80  LANT21     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   29

      02D3H    80  LANT22     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   31

      0373H    80  LANT23     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   33

      0413H    80  LANT24     INTEGER*2 DIMENSIONED COMMON EQUIVALENCED
                                4   15   35
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                          LDJMPS      EXTERNAL SUBROUTINE
                                       49

           2CA2H      2   LT          INTEGER*2
                                       64   246   248   319   353   360   362   364   365   372   373
                                      380   385

                          MFLAG       EXTERNAL SUBROUTINE
                                      364

                          MFPNUM      EXTERNAL SUBROUTINE
                                      353   357   360   362

                          MOD         INTRINSIC
                                       64   309   373

                          MSGOUT      EXTERNAL SUBROUTINE
                                       54    72    79    89   101   113   124   135   155   161   166
                                      179   185   190   201   208   213   220   227   233   236   267
                                      294   342   376   377

                          MSKSET      EXTERNAL SUBROUTINE
                                      278

           2CA0H      2   MX          INTEGER*2
                                       63    64   371   372   373

           00E3H      8   NC          INTEGER*1 DIMENSIONED COMMON
                                        3    16    27    54    72    73    79    80    89    90   101
                                      102   106   113   114   117   124   125   135   136   138   155
                                      156   161   162   166   167   168   179   180   185   186   190
                                      191   192   201   202   208   213   220   227   233   236   237
                                      267   291   294   334   342   344   376   377

                          NERD        EXTERNAL SUBROUTINE
                                      246

           2C5AH     16   NFEL        INTEGER*2 DIMENSIONED
                                        7   306   307   308   309   311   314   346

           244AH      1   NPASS       INTEGER*1
                                        3    61   251   370

           2C54H      2   NPZN        INTEGER*2
                                        7    87    92    94    97   121   206   364

           2CB2H      2   NZE         INTEGER*2
                                       86   336   337

           2CB0H      2   NZL         INTEGER*2
                                       85   336

           2CDAH      2   NZPAS       INTEGER*2
                                      242   255   257   264

           0074H     20   PARM        REAL*4 DIMENSIONED
                                        2   146   148   150   249   256   259   261   275   277   285
                                      296   297   301   302   303   306   319

           2CF6H      4   PC          REAL*4
                                      296   319   337   338   347   360

                          PCPN        EXTERNAL SUBROUTINE
                                      296

           2CF2H      4   PN          REAL*4
                                      296   319   336   338   362

           2D1AH      4   PR          REAL*4
                                      346   347

           0094H     20   PREV        REAL*4 DIMENSIONED
```

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                                   2  259  261
        2CB6H     4  RCAL         REAL*4
                                   95   98   99
                     RUNLMT       EXTERNAL SUBROUTINE
                                  259
        00A8H    32  SIGMA        REAL*4 DIMENSIONED
                                   2  325  348  357
        2CA8H     4  SLMDA        REAL*4
                                   83  206  306
        0088H    12  START        REAL*4 DIMENSIONED
                                   2  170  173  224
        2CE6H     4  SUM          REAL*4
                                  273  275
        2CC6H     4  SYSK         REAL*4
                                  117  119  121  211
        2CCCH     4  TO           REAL*4
                                  173  252  253  254
        2CDCH     4  T1           REAL*4
                                  249  252  253  254
        0020H    32  TANTL        REAL*4 DIMENSIONED
                                   2
        2CD6H     4  TC           REAL*4
                                  241  285  296
        2CE0H     4  TDEL         REAL*4
                                  254  270
        0098H    32  THETA        REAL*4 DIMENSIONED COMMON
                                   2   16   26  273  274  285  299  300  321
        2CEEH     4  TI           REAL*4
                                  277  279  296
                     UNPACK       EXTERNAL SUBROUTINE
                                  248
                     VALID        EXTERNAL SUBROUTINE
                                  256
        0010H     8  XDELF        REAL*4 DIMENSIONED COMMON
                                   2   16   21   84
        2D06H     4  XI           REAL*4
                                  302  305  306
        0000H     8  XLMDA        REAL*4 DIMENSIONED COMMON
                                   2   16   21   83
        0018H    32  XSYSK        REAL*4 DIMENSIONED COMMON
                                   2   16   22  121
        2D02H     4  XT           REAL*4
                                  301  302  303  304  305  306  317  319  338  339  347
                                  348
        2D0AH     4  YI           REAL*4
                                  303  306  319

MODULE INFORMATION:
```

```
CODE AREA SIZE      = 14CFH   5327D
VARIABLE AREA SIZE = 2D1EH  11550D
MAXIMUM STACK SIZE = 0016H     22D
656 LINES READ

0 PROGRAM ERROR(S) IN PROGRAM UNIT INTCOM

0 TOTAL PROGRAM ERROR(S)
END OF FORTRAN COMPILATION
```

```
ISIS-II OBJECT LOCATER V3.0 INVOKED BY:
-LOCATE :F1:SIGMAO.LNK TO :F1:SIGMAO CODE(4100H) COLUMNS(2) SYMBOLS &
**ORDER(CODE,DATA,//,/GG/,/A/,MEMORY) MAP PRINT(:LP:)

SYMBOL TABLE OF MODULE SIGMAO
READ FROM FILE :F1:SIGMAO.LNK
WRITTEN TO FILE :F1:SIGMAO

VALUE TYPE SYMBOL                                  VALUE TYPE SYMBOL

      MOD  INTCOM
4363H SYM  INTCOM                                  9E0DH SYM  CELL
D1D1H SYM  FNOIZ                                   9E2DH SYM  TANTL
9E4DH SYM  ANGT                                    D185H SYM  XLMDA
D18DH SYM  DTHETA                                  D19DH SYM  XSYSK
9E6DH SYM  ACOVR                                   D1E1H SYM  DLIM
D209H SYM  DFALT                                   9E81H SYM  PARM
D1BDH SYM  FCAL                                    D21DH SYM  THETA
9E95H SYM  START                                   D195H SYM  XDELF
D1D9H SYM  FPI3L                                   D1C9H SYM  BMWID
9EA1H SYM  PREV                                    9EB5H SYM  SIGMA
9ED5H SYM  IOBUF                                   9F11H SYM  INERD
9F4DH SYM  IOVER                                   9F11H SYM  IRESP
9F52H SYM  IOUT                                    D5E8H SYM  IFATAL
D268H SYM  NC                                      D256H SYM  IYN
D258H SYM  ILC                                     C252H SYM  IBCD
D23DH SYM  IOVRQ                                   D262H SYM  KXP
C256H SYM  IWAIT                                   D61AH SYM  IFAERR
C257H SYM  NPASS                                   D6DBH SYM  KESC
C258H SYM  IBL                                     C259H SYM  IAUTR
C25AH SYM  IAUTP                                   C25BH SYM  IBOVF
D267H SYM  IMSK                                    C25CH SYM  IOFLG
D624H SYM  INZERR                                  D368H SYM  LANT11
D3B8H SYM  LANT21                                  D408H SYM  LANT12
D458H SYM  LANT22                                  D4A8H SYM  LANT13
D4F8H SYM  LANT23                                  D548H SYM  LANT14
D598H SYM  LANT24                                  D270H SYM  CANT1
D2AEH SYM  CANT2                                   D2ECH SYM  CANT3
D32AH SYM  CANT4                                   9F11H SYM  IPLZ
D25AH SYM  IPOLZ                                   C261H SYM  IPSD
D368H SYM  IGTBL                                   D270H SYM  IGTBC
D642H SYM  ICLC                                    CA61H SYM  NPZN
CA63H SYM  IBND                                    CA65H SYM  ICNT
CA67H SYM  NFEL                                    CA77H SYM  IFDL
CA87H SYM  IBPT                                    CA97H SYM  INZ
D23DH SYM  CIOVRQ                                  D5E8H SYM  CFATAL
D256H SYM  CIYN                                    D258H SYM  CILC
D25AH SYM  CIPOLZ                                  D642H SYM  CCLC
D61AH SYM  CFAERR                                  9F11H SYM  CRESP
9ED5H SYM  CIOBUF                                  9F11H SYM  CNERD
D62EH SYM  IBFLW                                   D638H SYM  ICALW
D665H SYM  CL                                      D67DH SYM  CC
D6B5H SYM  CST                                     D6D9H SYM  IEOC
437BH SYM  ?5                                      CA99H SYM  IEFLG
CA9BH SYM  @IOPB                                   427AH SYM  ?21
554AH SYM  ?7000                                   43CEH SYM  ?40
CAADH SYM  MX                                      CAAFH SYM  LT
4452H SYM  ?115                                    4412H SYM  ?85
4B09H SYM  ?740                                    CAB1H SYM  BMW
CAB5H SYM  SLMDA                                   CAB9H SYM  DELF
CABDH SYM  NZL                                     CABFH SYM  NZE
44ECH SYM  ?160                                    4540H SYM  ?180
CAC1H SYM  L                                       CAC3H SYM  RCAL
458DH SYM  ?200                                    4574H SYM  ?195
4584H SYM  ?196                                    CAC7H SYM  IFCAL
45B5H SYM  ?203                                    4620H SYM  ?255
CAC9H SYM  IERR                                    CACBH SYM  DTHEI
462FH SYM  ?260                                    CACFH SYM  DTHER
464CH SYM  ?305                                    46CDH SYM  ?380
CAD3H SYM  SYSK                                    46E3H SYM  ?385
4728H SYM  ?415                                    CAD7H SYM  J
48C7H SYM  ?500                                    4815H SYM  ?475
429DH SYM  ?430                                    47F9H SYM  ?473
47BDH SYM  ?460                                    48BDH SYM  ?490
485AH SYM  ?481                                    487CH SYM  ?482
489EH SYM  ?483                                    4908H SYM  ?545
48D3H SYM  ?520                                    4A13H SYM  ?625
493AH SYM  ?570                                    4A0EH SYM  ?620
42BEH SYM  ?600                                    CAD9H SYM  TO
4A54H SYM  ?655                                    4A1FH SYM  ?630
```

```
4A86H SYM  ?680                    4B04H SYM  ?730
42C5H SYM  ?710                    CADDH SYM  DELT
4D82H SYM  ?870                    42CBH SYM  ?790
42F4H SYM  ?815                    4C9AH SYM  ?860
4319H SYM  ?850                    4D25H SYM  ?865
4CB3H SYM  ?862                    432EH SYM  ?864
CAE1H SYM  I                       4D34H SYM  ?866
434BH SYM  ?868                    CAE3H SYM  TC
CAE7H SYM  NZPAS                   4DD2H SYM  ?915
4DD5H SYM  ?925                    CAE9H SYM  T1
4E23H SYM  ?930                    4E3BH SYM  ?940
4E32H SYM  ?935                    4E4DH SYM  ?945
CAEDH SYM  TDEL                    4E88H SYM  ?950
4E95H SYM  ?955                    4EBBH SYM  ?960
CAF1H SYM  K                       4EF8H SYM  ?965
4F19H SYM  ?977                    4F07H SYM  ?975
556EH SYM  ?7777                   4F28H SYM  ?1000
4F7BH SYM  ?1005                   CAF3H SYM  SUM
CAF7H SYM  DIFF                    CAFBH SYM  TI
4F92H SYM  ?1030                   5001H SYM  ?1050
500BH SYM  ?1060                   5026H SYM  ?1100
501AH SYM  ?1065                   CAFFH SYM  PN
CB03H SYM  PC                      CB07H SYM  AROL
52BAH SYM  ?1305                   CB0BH SYM  ANGL
CB0FH SYM  XT                      CB13H SYM  XI
CB17H SYM  YI                      CB1BH SYM  BNDW
CB1FH SYM  FDOP                    51ABH SYM  ?1200
51D0H SYM  ?1210                   CB23H SYM  ANGTL
52C4H SYM  ?1310                   52DBH SYM  ?1650
52FAH SYM  ?1657                   5304H SYM  ?1660
536BH SYM  ?1689                   5375H SYM  ?1690
53D1H SYM  ?1700                   CB27H SYM  PR
541BH SYM  ?1800                   5431H SYM  ?1900
5588H SYM  ?777
      MOD  IUSART
0027H SYM  CMD                     00CDH SYM  CNCTL
00CEH SYM  MODE                    55CFH SYM  IUSRT
      MOD  DVERIF
55D8H SYM  ASCDV                   5628H SYM  CO
5602H SYM  CC0                     5611H SYM  CP0
561FH SYM  CP1                     561AH SYM  CP2
55F0H SYM  DC                      55DDH SYM  GC
55EAH SYM  STP                     55E8H SYM  STP0
      MOD  KEYIN
0008H SYM  BACK                    0007H SYM  BELL
000DH SYM  CR                      564AH SYM  BKSPC
5674H SYM  CI                      565CH SYM  FILL
566DH SYM  GETCH                   5631H SYM  KEYBRD
5635H SYM  NEXT                    5652H SYM  SKIP1
5663H SYM  SKIP2
      MOD  OUTPUT
5681H SYM  GBYT                    567EH SYM  MSGOUT
5693H SYM  XIT
      MOD  ICRLF
000DH SYM  CR                      001BH SYM  ESC
000AH SYM  LF                      56B6H SYM  CO
5694H SYM  CRLF                    56C1H SYM  DELAY
56A3H SYM  ECH05                   56B4H SYM  ECH10
569AH SYM  ECHO                    56C5H SYM  LOOP
      MOD  GETVLU
56ECH SYM  GETVLU                  CB2BH SYM  CIOBUF
CB2FH SYM  IOBUFF                  CB31H SYM  N10
CB33H SYM  N20                     CB35H SYM  IERR
CB37H SYM  XNUM                    CB2DH SYM  CIOBUF@
571DH SYM  ?5                      CB39H SYM  @IOPB
56CFH SYM  ?10                     57B9H SYM  ?50
5750H SYM  ?15                     575CH SYM  ?20
5768H SYM  ?25                     5774H SYM  ?30
56E6H SYM  ?35                     57C5H SYM  ?51
57D1H SYM  ?52                     57B8H SYM  ?40
      MOD  IBFILL
57DDH SYM  IBFILL                  57E0H SYM  LL1
57E2H SYM  LL2
      MOD  DWAIT
57EEH SYM  DWAIT                   57F3H SYM  LOOP
5804H SYM  LP2
      MOD  RUNLMT
5816H SYM  RUNLMT                  CB4BH SYM  PREV
CB4DH SYM  IOVER                   CB4FH SYM  PARM
CB51H SYM  LZ                      CB52H SYM  UZ
```

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5898H SYM  ?10                          CB53H SYM  AL
CB57H SYM  AU                           593CH SYM  ?20
CB5BH SYM  L                            59C8H SYM  ?30
      MOD  UNPACK
59E2H SYM  RR4B                         59CEH SYM  STEP
59C9H SYM  UNPACK
      MOD  LDJMPS
4020H SYM  LDJMPS
      MOD  DECODA
59E7H SYM  DECODA                       CB5DH SYM  IOV
CB5FH SYM  NERZ                         CB61H SYM  T1
CB63H SYM  PARM                         [illegible] SYM  II
D665H SYM  CL                           [illegible] SYM  CC
D6B5H SYM  CST                          59FDH SYM  ?10
5A63H SYM  ?30                          5A40H SYM  ?20
CB6FH SYM  K                            5A4AH SYM  ?25
5B1FH SYM  ?50                          CB71H SYM  J
5A94H SYM  ?35                          5AD4H SYM  ?40
CB73H SYM  L                            5B29H SYM  ?60
5B93H SYM  ?80                          5B70H SYM  ?70
5BBFH SYM  ?85
      MOD  KEYCHK
5C78H SYM  KEYCHK                       5C95H SYM  XIT
      MOD  VALID
5C96H SYM  VALID                        CB75H SYM  DL
CB77H SYM  DF                           CB79H SYM  IOV
CB7BH SYM  IVAL                         CB7DH SYM  PARM
CB7FH SYM  LZ                           CB80H SYM  UZ
CB81H SYM  KK                           5D95H SYM  ?20
CB83H SYM  K                            CB85H SYM  IDFG
5D6BH SYM  ?10
      MOD  MFLAG
5DA0H SYM  MFLAG                        CB87H SYM  IC
CB89H SYM  IOF                          CB8BH SYM  IOUT
CB8DH SYM  IB                           CB8FH SYM  NZ
5D5BH SYM  ?10                          CB91H SYM  I
5E43H SYM  ?20                          CB93H SYM  K
      MOD  MFPNUM
5E56H SYM  MFPNUM                       CB95H SYM  FPNBR
CB97H SYM  ICOL                         CB99H SYM  IBPT
CB9BH SYM  IOUT                         CB9DH SYM  IBCD
CB9FH SYM  NK                           6029H SYM  ?30
CBA1H SYM  K                            CBA3H SYM  FP
CBA7H SYM  INUM                         5F2AH SYM  ?5
5F82H SYM  ?10                          CBA9H SYM  J
CBABH SYM  IH                           5F9AH SYM  ?15
601FH SYM  ?20                          CBADH SYM  L
CBAFH SYM  INDX
      MOD  KBPHAL
6034H SYM  KBPHAL                       CBB3H SYM  IOUT
CBB5H SYM  J                            6077H SYM  ?10
      MOD  INIT
00EBH SYM  C8255                        00A6H SYM  CW8255
00ECH SYM  D8251                        00E8H SYM  D8255
00E9H SYM  DATA                         0008H SYM  DATB
0009H SYM  DMA                          0020H SYM  EOI
0009H SYM  FILB                         00DDH SYM  FILD
001FH SYM  ICW1                         0040H SYM  ICW2
000DH SYM  INTEA                        0005H SYM  INTEB
0008H SYM  LDADN                        000AH SYM  LSB
00FFH SYM  MASK                         000BH SYM  MSB
0020H SYM  OCW2                         00FDH SYM  UMASK
00E7H SYM  UNSTB                        00EFH SYM  UNSYN
60D0H SYM  BPLISR                       60BFH SYM  CZT
60C3H SYM  CZTR                         60BDH SYM  DSABLE
60FFH SYM  FNSH                         60C6H SYM  IBIPHL
60A2H SYM  INI259                       607BH SYM  INICZT
60E2H SYM  INIPIO                       60B5H SYM  INTSET
60C8H SYM  LOAD                         60B1H SYM  MSKSET
60DBH SYM  NERD                         60EAH SYM  STB
      MOD  IKEYI
610AH SYM  IKEYI                        D6DBH SYM  KESC
D6D9H SYM  IEOC
      MOD  CZTINT
6110H SYM  CZTINT
      MOD  IENDI
6125H SYM  IENDI                        D6DBH SYM  KESC
D6D9H SYM  IEOC
      MOD  AMDMUL
0012H SYM  MULT                         612CH SYM  AMDMUL
```

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```
      MOD  AMDIV
0013H SYM  FDIV                 613FH SYM  AMDIV
      MOD  FDLEV
0013H SYM  FDIV                 001FH SYM  FIX
006CH SYM  IAD                  006FH SYM  IDIV
006DH SYM  ISUB                 6152H SYM  FDLEV
6187H SYM  TWO
      MOD  CBNDW
001DH SYM  FLOT                 0012H SYM  MULT
6189H SYM  CBNDW
      MOD  GXI
0003H SYM  COS                  0019H SYM  EXCHG
0010H SYM  FADD                 0012H SYM  MULT
0002H SYM  SIN                  0004H SYM  TAN
61A1H SYM  GXI
      MOD  GYI
0003H SYM  COS                  0019H SYM  EXCHG
0011H SYM  FSUB                 0012H SYM  MULT
0002H SYM  SIN                  0004H SYM  TAN
61DFH SYM  GYI
      MOD  CLNPT
0005H SYM  ASIN                 0010H SYM  FADD
0012H SYM  FMUL                 0011H SYM  FSUB
0074H SYM  ICHS                 001FH SYM  IFIX
006DH SYM  ISUB                 0017H SYM  PUSHT
0004H SYM  TAN                  6222H SYM  CLNPT
CBB7H SYM  HOLD
      MOD  AMDSUB
0011H SYM  SUBT                 62A8H SYM  AMDSUB
      MOD  AMDADD
0010H SYM  RADD                 62BBH SYM  AMDADD
      MOD  INTGT
0010H SYM  FADD                 001FH SYM  FIX
0012H SYM  MULT                 62F1H SYM  HALF
62CEH SYM  INTGT
      MOD  FDLOD
0010H SYM  FADD                 0013H SYM  FDIV
001FH SYM  FIX                  006CH SYM  IAD
006FH SYM  IDIV                 006DH SYM  ISUB
62F5H SYM  FDLOD                6340H SYM  HALF
6344H SYM  ONE                  6346H SYM  TWO
      MOD  GIVE
00F0H SYM  PORT                 6348H SYM  GIVE
      MOD  GET
00F0H SYM  PORT                 6364H SYM  BSY
6361H SYM  GET
      MOD  INTLOD
00F0H SYM  PORT                 637AH SYM  INTLOD
      MOD  INTSTR
00F0H SYM  PORT                 6388H SYM  INTSTR
      MOD  AMDLOD
00F0H SYM  PORT                 6397H SYM  AMDLOD
63BFH SYM  LABEL1               63CBH SYM  LABEL2
63CEH SYM  LABEL3
      MOD  ALTFP
001DH SYM  FLOAT                006CH SYM  IAD
006EH SYM  IMULT                0012H SYM  MULT
63D1H SYM  ALTFP                6425H SYM  TEN
      MOD  DRPFP
0013H SYM  DIV                  001DH SYM  FLOAT
006CH SYM  IAD                  006EH SYM  IMULT
0012H SYM  MULT                 6427H SYM  DRPFP
6470H SYM  TEN
      MOD  VELFP
0013H SYM  DIV                  001DH SYM  FLOAT
006CH SYM  IAD                  006EH SYM  IMULT
0012H SYM  MULT                 64B2H SYM  TEN
6472H SYM  VELFP
      MOD  TSECS
006CH SYM  IAD                  006EH SYM  IMULT
64E6H SYM  TEN                  64B4H SYM  TSECS
      MOD  PCPN
0013H SYM  DIV                  0017H SYM  ENTR
0019H SYM  EXCHG                0012H SYM  MULT
00F0H SYM  PORT                 6526H SYM  HALF
64E8H SYM  PCPN
      MOD  CELCNT
0010H SYM  AD                   0013H SYM  DIV
001FH SYM  FIX                  0012H SYM  MULT
00F0H SYM  PORT                 0004H SYM  TAN
```

```
652AH SYM  CELCNT                          6564H SYM  HALF
      MOD  AMDCMD
00F0H SYM  PORT                            0018H SYM  PULL
6568H SYM  AMDCMD                          6573H SYM  BUSY
6569H SYM  BZY                             6595H SYM  LOOP
65AAH SYM  LOOP2                           65B0H SYM  NOERR
65A6H SYM  UNDFLO
      MOD  AMDSTR
00F0H SYM  PORT                            0018H SYM  PULL
65B3H SYM  AMDSTR                          65DDH SYM  BACK
65B7H SYM  BUSY                            65EBH SYM  NOERR
65F8H SYM  SKIP1                           65FAH SYM  SKIP2
65E5H SYM  UNDFLO
      MOD  CNFILT
0007H SYM  ATAN                            0003H SYM  COS
0010H SYM  FADD                            0013H SYM  FDIV
001FH SYM  FIX                             0012H SYM  MULT
0017H SYM  PUSHT                           0002H SYM  SIN
0001H SYM  SQRT                            660DH SYM  CNFILT
6706H SYM  HALF                            CBBBH SYM  ISAVE
      MOD  IBELL
670AH SYM  IBELL
      MOD  GXT
0011H SYM  FSUB                            0012H SYM  MULT
0017H SYM  PUSHT                           0001H SYM  SQRT
0004H SYM  TAN                             6710H SYM  GXT
      MOD  MINHR
006CH SYM  IAD                             006EH SYM  IMULT
6777H SYM  I10                             6759H SYM  MINHR
      MOD  TIMEFP
0010H SYM  AD                              0013H SYM  DIV
001DH SYM  FLOAT                           006CH SYM  IAD
006EH SYM  IMULT                           0012H SYM  MULT
67C6H SYM  F10                             67C2H SYM  F60
67C0H SYM  I60                             6779H SYM  TIMEFP
      MOD  CCELL
0012H SYM  MULT                            00F0H SYM  PORT
0011H SYM  SUBT                            0004H SYM  TAN
67CAH SYM  CCELL
      MOD  I32SUM
001CH SYM  FLOT32                          002CH SYM  IADD32
0008H SYM  LOG                             0012H SYM  MULT
6805H SYM  FLOAT                           67F0H SYM  I32SUM
67F6H SYM  LOOP                            681FH SYM  TEN
      MOD  I32LOD
00F0H SYM  PORT                            6823H SYM  I32LOD

MEMORY MAP OF MODULE SIGMAO
READ FROM FILE :F1:SIGMAO.LNK
WRITTEN TO FILE :F1:SIGMAO
MODULE START ADDRESS 4363H

START    STOP LENGTH REL NAME

4000H  4020H    21H   A  ABSOLUTE
4100H  9E0CH  5D0DH   B  CODE
9E0DH  D184H  3378H   B  DATA
D185H  D664H   4E0H   B  //
D665H  D6D8H    74H   B  /GG/
D6D9H  D6DBH     3H   B  /A/
D6DCH  F6BFH  1FE4H   B  MEMORY
F6C0H  F854H   195H   B  STACK
```

APPENDIX C

Bi-Phase-L Output Frame

Bi-Phase L Output Data Format

CONTENT (H means Hex)		WORD Nbr (4 Bits Each)
SYNC	FH	1
SYNC	BH	2
SYNC	FH	3
FRAME		4
TIME, SEC. (Tenths)		5
TIME, SEC. (Units)		6
TIME, SEC. (Tens)		7
TIME, MIN. (Units)		8
TIME, MIN. (Tens)		9
(Same As Input NERDAS)		
FLIGHT Nbr (Units)		103
FLIGHT Nbr (Tens)		104
LINE Nbr (Units)		105
LINE Nbr (Tens)		106
RUN Nbr (Units)		107
LINE START (Units)		108
ANGLE 1 (Tenths)		109
ANGLE 1 (Units)		110
ANGLE 1 (Tens)		111

Bi-Phase L Output Data Format (continued)

CONTENT (H means Hex)		WORD Nbr (4 Bits Each)
ANGLE 1	(Sign)	112
ANGLE 2	(Tenths)	113
ANGLE 2	(Units)	114
ANGLE 2	(Tens)	115
ANGLE 2	(Sign)	116
--------	--------	--------
--------	--------	--------
ANGLE 8	(Tenths)	137
ANGLE 8	(Units)	138
ANGLE 8	(Tens)	139
ANGLE 8	(Sign)	140
SIGMA 1	(Tenths)	141
SIGMA 1	(Units)	142
SIGMA 1	(Tens)	143
SIGMA 1	(Sign)	144
SIGMA 2	(Tenths)	145
SIGMA 2	(Units)	146
SIGMA 2	(Tens)	147
SIGMA 2	(Sign)	148
--------	--------	--------
SIGMA 8	(Tenths)	169
SIGMA 8	(Units)	170
SIGMA 8	(Tens)	171

Bi-Phase L Output Data Format (continued)

CONTENT (H means Hex)		WORD Nor (4 Bits Each)
SIGMA 8	(Sign	172
CPWR	(Tenths)	173
CPWR	(Units)	174
CPWR	(Tens)	175
CPWR	(Sign)	176
NPWR	(Tenths)	177
NPWR	(Units)	178
NPWR	(Tens)	179
NPWR	(Sign)	180
NPZN	(Units)	181
IVALB	(Units)	182
SALARM	(Units)	183
ISYSK	(Units)	184
IOVRB	(Units)	185
IBND	(Units)	186
ITHE	(Units)	187
DDH	Frame End Fill	188

DDH	Identified [illegible]	225
DDH	DD_{HEX}	256

APPENDIX D

Subroutine Listings (Alphabetical)

```
ASM80 :F1:AFLOAT.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AFLOAT    PAGE     1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME    AFLOAT
                       2 ;        SUBROUTINE AFLOAT(IN,FP)
                       3 ;
                       4 ;        ::: FP=FLOAT(IN)
                       5 ;
  001D                 6 FLOAT    EQU     1DH
                       7 ;
                       8 EXTRN    INTLOD,AMDSTR,AMDCMD
                       9 ;
                      10 PUBLIC   AFLOAT
                      11 ;
                      12 CSEG
                      13 ;
  0000 E1             14 AFLOAT:  POP     H        ;SAVE RETURN ADDR
  0001 CD0000    E    15          CALL    INTLOD   ;IN ↑
  0004 3E1D           16          MVI     A,FLOAT
  0006 CD0000    E    17          CALL    AMDCMD   ;FLOAT(IN)
  0009 42             18          MOV     B,D
  000A 4B             19          MOV     C,E
  000B CD0000    E    20          CALL    AMDSTR   ;FP=FLOAT(IN)
  000E E9             21          PCHL             ;RETURN
                      22 ;
                      23          END

PUBLIC SYMBOLS
AFLOAT C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDSTR E 0000    INTLOD E 0000

USER SYMBOLS
AFLOAT C 0000    AMDCMD E 0000    AMDSTR E 0000    FLOAT  A 001D    INTLOD E 0000

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:AINDX.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         AINDX     PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME     AINDX
                       2 ;        SUBROUTINE AINDX(IX,I80,TEN,AGL,RAD)
                       3 ;
                       4 ;        ;;; IX=IFIX(AGL*RAD-TEN)+I80
                       5 ;
  0012                 6 MULT     EQU      12H
  0011                 7 SUBT     EQU      11H
  001F                 8 FIX      EQU      1FH
  006C                 9 IAD      EQU      6CH
                      10 ;
                      11 EXTRN    AMDLOD,INTLOD,INTSTR,AMDCMD
                      12 ;
                      13 PUBLIC   AINDX
                      14 ;
                      15 CSEG
                      16 ;
  0000 E1             17 AINDX:   POP      H        ;SAVE RTN ADDR
  0001 CD0000    E    18          CALL     AMDLOD   ;AGL ↑
  0004 42             19          MOV      B,D
  0005 4B             20          MOV      C,E
  0006 CD0000    E    21          CALL     AMDLOD   ;RAD ↑
  0009 3E12           22          MVI      A,MULT
  000B CD0000    E    23          CALL     AMDCMD   ;AGL*RAD
  000E C1             24          POP      B
  000F CD0000    E    25          CALL     AMDLOD   ;TEN ↑
  0012 3E11           26          MVI      A,SUBT
  0014 CD0000    E    27          CALL     AMDCMD   ;AGL*RAD-TEN
  0017 3E1F           28          MVI      A,FIX
  0019 CD0000    E    29          CALL     AMDCMD   ;IFIX(AGL*RAD-TEN)
  001C C1             30          POP      B
  001D CD0000    E    31          CALL     INTLOD   ;I80 ↑
  0020 3E6C           32          MVI      A,IAD
  0022 CD0000    E    33          CALL     AMDCMD   ; + I80
  0025 C1             34          POP      B
  0026 CD0000    E    35          CALL     INTSTR   ;IX=RESULT
  0029 E9             36          PCHL              ;RETURN
                      37 ;
                      38          END

PUBLIC SYMBOLS
AINDX  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AINDX  C 0000    AMDCMD E 0000    AMDLOD E 0000    FIX    A 001F    IAD    A 006C
INTLOD E 0000    INTSTR E 0000    MULT   A 0012    SUBT   A 0011

ASSEMBLY COMPLETE,    NO ERRORS
```

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```
ASM80 :F1:ALTFP.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          ALTFP     PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1 ;        SUBROUTINE ALTFP(ALT,CALT,ITN,IHD,ITH,IUN)
                      2 ;
                      3          NAME     ALTFP
                      4 ;
                      5 ;
                      6 ;        EVALUATES ALTITUDE IN METERS:
                      7 ;
                      8 ;                 ALT=FLOAT(IUN+10*(ITN+10*(IHD+10*ITH)))*CALT
                      9 ;
  0012               10 MULT     EQU      12H
  006C               11 IAD      EQU      6CH
  006E               12 IMULT    EQU      6EH
  001D               13 FLOAT    EQU      1DH
                     14 ;
                     15          EXTRN    INTLOD,AMDCMD,AMDSTR,AMDLOD
                     16          PUBLIC   ALTFP
                     17 ;
                     18          CSEG
                     19 ;
  0000 E1            20 ALTFP:   POP      H                 ;SAVE RETURN ADDRESS
  0001 CD0000    E   21          CALL     INTLOD            ;ITH ↑
  0004 015400    C   22          LXI      B,TEN
  0007 CD0000    E   23          CALL     INTLOD            ;10 ↑
  000A 3E6E          24          MVI      A,IMULT
  000C CD0000    E   25          CALL     AMDCMD            ;X
  000F C1            26          POP      B
  0010 CD0000    E   27          CALL     INTLOD            ;IHD
  0013 3E6C          28          MVI      A,IAD
  0015 CD0000    E   29          CALL     AMDCMD            ;+
  0018 015400    C   30          LXI      B,TEN
  001B CD0000    E   31          CALL     INTLOD            ;10 ↑
  001E 3E6E          32          MVI      A,IMULT
  0020 CD0000    E   33          CALL     AMDCMD            ;X
  0023 C1            34          POP      B
  0024 CD0000    E   35          CALL     INTLOD            ;ITN ↑
  0027 3E6C          36          MVI      A,IAD
  0029 CD0000    E   37          CALL     AMDCMD            ;+
  002C 015400    C   38          LXI      B,TEN
  002F CD0000    E   39          CALL     INTLOD            ;10 ↑
  0032 3E6E          40          MVI      A,IMULT
  0034 CD0000    E   41          CALL     AMDCMD            ;X
  0037 42            42          MOV      B,D
  0038 4B            43          MOV      C,E
  0039 CD0000    E   44          CALL     INTLOD            ;IUN ↑
  003C 3E6C          45          MVI      A,IAD
  003E CD0000    E   46          CALL     AMDCMD            ;+
  0041 3E1D          47          MVI      A,FLOAT
  0043 CD0000    E   48          CALL     AMDCMD            ;FLOAT
  0046 C1            49          POP      B
  0047 CD0000    E   50          CALL     AMDLOD            ;CALT ↑
  004A 3E12          51          MVI      A,MULT
  004C CD0000    E   52          CALL     AMDCMD            ;X
  004F C1            53          POP      B
  0050 CD0000    E   54          CALL     AMDSTR            ;SAVE IN ALT
  0053 E9            55          PCHL                       ;RETURN
  0054 0A00          56 TEN:     DW       10
                     57          END

PUBLIC SYMBOLS
ALTFP  C 0000

EXTERNAL SYMBOLS
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          ALTFP    PAGE    2

AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000

USER SYMBOLS
ALTFP  C 0000    AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    FLOAT  A 001D
IAD    A 006C    IMULT  A 006E    INTLOD E 0000    MULT   A 0012    TEN    C 0054

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:AMDADD.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        AMDADD   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT
                     1          NAME AMDADD
                     2 ;
                     3 ;        SUBROUTINE AMDADD(R,A1,A2)
                     4 ;
                     5 ;        ::: R=A1+A2
                     6 ;
  0010               7 RADD     EQU     10H
                     8 ;
                     9 EXTRN    AMDLOD,AMDCMD,AMDSTR
                    10 ;
                    11 PUBLIC   AMDADD
                    12 ;
                    13 CSEG
                    14 ;
  0000 E1           15 AMDADD:  POP     H       ;SAVE RETURN ADDR
  0001 CD0000   E   16          CALL    AMDLOD  ;A1 ↑
  0004 42           17          MOV     B,D
  0005 4B           18          MOV     C,E
  0006 CD0000   E   19          CALL    AMDLOD  ;A2 ↑
  0009 3E10         20          MVI     A,RADD
  000B CD0000   E   21          CALL    AMDCMD  ;A1+A2
  000E C1           22          POP     B
  000F CD0000   E   23          CALL    AMDSTR  ;R=A1+A2
  0012 E9           24          PCHL            ;RETURN
                    25          ;
                    26          END

PUBLIC SYMBOLS
AMDADD C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDADD C 0000    AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    RADD    A 0010

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:AMDGSQ.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         AMDGSQ   PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT
                       1 ;        SUBROUTINE AMDGSQ(GSQ,DGN,IGT,TEN)
                       2 ;
                       3 ;        !!! GSQ=FLOAT(IGT)/TEN+DGN
                       4 ;
                       5          NAME    AMDGSQ
                       6 ;
  001D                 7 AFLOAT   EQU     1DH
  0013                 8 ADIV     EQU     13H
  0010                 9 FADD     EQU     10H
                      10 ;
                      11 PUBLIC   AMDGSQ
                      12 EXTRN    AMDLOD,INTLOD,AMDSTR,AMDCMD
                      13 ;
                      14 CSEG
                      15 ;
  0000 E1             16 AMDGSQ:  POP     H        ;SAVE RTN ADDR
  0001 CD0000    E    17          CALL    INTLOD   ;IGT ↑
  0004 3E1D           18          MVI     A,AFLOAT
  0006 CD0000    E    19          CALL    AMDCMD   ;FLOAT(IGT)
  0009 42             20          MOV     B,D
  000A 4B             21          MOV     C,E
  000B CD0000    E    22          CALL    AMDLOD   ;TEN ↑
  000E 3E13           23          MVI     A,ADIV
  0010 CD0000    E    24          CALL    AMDCMD   ;FLOAT(IGT)/TEN
  0013 C1             25          POP     B
  0014 CD0000    E    26          CALL    AMDLOD   ;DGN ↑
  0017 3E10           27          MVI     A,FADD
  0019 CD0000    E    28          CALL    AMDCMD   ;+
  001C C1             29          POP     B
  001D CD0000    E    30          CALL    AMDSTR   ;SAVE RESULT AT GSQ
  0020 E9             31          PCHL             ;RETURN
                      32          END

PUBLIC SYMBOLS
AMDGSQ C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000     AMDSTR E 0000     INTLOD E 0000

USER SYMBOLS
ADIV   A 0013    AFLOAT A 001D     AMDCMD E 0000     AMDGSQ C 0000     AMDLOD E 0000
AMDSTR E 0000    FADD   A 0010     INTLOD E 0000

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:AMDGN.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDGN    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1 ;       SUBROUTINE AMDGN(DGN,TWO,DG,TEN,I1,I2)
                       2 ;
                       3 ;       :::: DGN=(FLOAT(I1-I2)/TEN)*DG/TWO
                       4 ;
                       5         NAME    AMDGN
                       6 ;
  001D                 7 AFLOAT  EQU     1DH
  0013                 8 ADIV    EQU     13H
  0012                 9 MULT    EQU     12H
  006D                10 ISUB    EQU     6DH
                      11 ;
                      12 EXTRN   AMDLOD,INTLOD,AMDSTR,AMDCMD
                      13 ;
                      14 PUBLIC  AMDGN
                      15 ;
                      16 CSEG
                      17 ;
  0000 E1             18 AMDGN:  POP     H          ;PICK OFF RETURN ADDR
  0001 CD0000    E    19         CALL    INTLOD     ;I1 ↑
  0004 42             20         MOV     B,D
  0005 4B             21         MOV     C,E
  0006 CD0000    E    22         CALL    INTLOD     ;I2 ↑
  0009 3E6D           23         MVI     A,ISUB
  000B CD0000    E    24         CALL    AMDCMD     ;I1-I2
  000E 3E1D           25         MVI     A,AFLOAT
  0010 CD0000    E    26         CALL    AMDCMD     ;FLOAT(I1-I2)
  0013 C1             27         POP     B
  0014 CD0000    E    28         CALL    AMDLOD     ;TEN ↑
  0017 3E13           29         MVI     A,ADIV
  0019 CD0000    E    30         CALL    AMDCMD     ;FLOAT(I1-I2)/TEN
  001C C1             31         POP     B
  001D CD0000    E    32         CALL    AMDLOD     ;DG ↑
  0020 3E12           33         MVI     A,MULT
  0022 CD0000    E    34         CALL    AMDCMD     ;FLOAT(I1-I2)/TEN*DG
  0025 C1             35         POP     B
  0026 CD0000    E    36         CALL    AMDLOD     ;TWO ↑
  0029 3E13           37         MVI     A,ADIV
  002B CD0000    E    38         CALL    AMDCMD     ;( ... )*DG/TWO
  002E C1             39         POP     B
  002F CD0000    E    40         CALL    AMDSTR     ;SAVE RESULT AT DGN
  0032 E9             41         PCHL               ;RETURN
                      42         END

 PUBLIC SYMBOLS
 AMDGN  C 0000

 EXTERNAL SYMBOLS
 AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000

 USER SYMBOLS
 ADIV   A 0013    AFLOAT A 001D    AMDCMD E 0000    AMDGN  C 0000    AMDLOD E 0000
 AMDSTR E 0000    INTLOD E 0000    ISUB   A 006D    MULT   A 0012

 ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:AMDMUL.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDMUL    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1              NAME     AMDMUL
                       2 ;            SUBROUTINE AMDMUL(R,A1,A2)
                       3 ;
                       4 ;            ;;; R=A1*A2
                       5 ;
  0012                 6 MULT         EQU      12H
                       7 ;
                       8 EXTRN        AMDLOD,AMDSTR,AMDCMD
                       9 ;
                      10 PUBLIC       AMDMUL
                      11 ;
                      12 CSEG
                      13 ;
  0000 E1             14 AMDMUL:      POP      H          ;SAVE RTN ADDR
  0001 CD0000    E    15              CALL     AMDLOD     ;A1 ↑
  0004 42             16              MOV      B,D
  0005 4B             17              MOV      C,E
  0006 CD0000    E    18              CALL     AMDLOD     ;A2 ↑
  0009 3E12           19              MVI      A,MULT
  000B CD0000    E    20              CALL     AMDCMD     ;A1*A2
  000E C1             21              POP      B
  000F CD0000    E    22              CALL     AMDSTR     ;R=A1*A2
  0012 E9             23              PCHL                ;RETURN
                      24 ;
                      25              END

PUBLIC SYMBOLS
AMDMUL C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDMUL C 0000    AMDSTR E 0000    MULT   A 0012

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:AMDSUB.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDSUB    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME     AMDSUB
                       2 ;        SUBROUTINE AMDSUB(R,A1,A2)
                       3 ;
                       4 ;        ;;; R=A1-A2
                       5 ;
  0011                 6 SUBT     EQU      11H
                       7 ;
                       8 EXTRN    AMDCMD,AMDLOD,AMDSTR
                       9 ;
                      10 PUBLIC   AMDSUB
                      11 ;
                      12 CSEG
                      13 ;
  0000 E1             14 AMDSUB:  POP      H        ;SAVE RTN ADDR
  0001 CD0000    E    15          CALL     AMDLOD   ;A1 ↑
  0004 42             16          MOV      B,D
  0005 4B             17          MOV      C,E
  0006 CD0000    E    18          CALL     AMDLOD   ;A2 ↑
  0009 3E11           19          MVI      A,SUBT
  000B CD0000    E    20          CALL     AMDCMD   ;A1-A2
  000E C1             21          POP      B
  000F CD0000    E    22          CALL     AMDSTR   ;R=A1-A2
  0012 E9             23          PCHL              ;RETURN
                      24          ;
                      25          END

PUBLIC SYMBOLS
AMDSUB C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    AMDSUB C 0000    SUBT   A 0011

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:CBNDW.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        CBNDW    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME    CBNDW
                       2 ;
                       3 ;        SUBROUTINE CBNDW(BNDW,NFEL,DELF)
                       4 ;
                       5 ;        !!! BNDW=FLOAT(NFEL)*DELF
                       6 ;
  001D                 7 FLOT     EQU     1DH
  0012                 8 MULT     EQU     12H
                       9 ;
                      10 EXTRN    INTLOD,AMDLOD,AMDSTR,AMDCMD
                      11 ;
                      12 PUBLIC   CBNDW
                      13 ;
                      14 CSEG
                      15 ;
  0000 E1             16 CBNDW:   POP     H       ;SAVE RTN ADDR
  0001 CD0000     E   17          CALL    INTLOD  ;NFEL ↑
  0004 3E1D           18          MVI     A,FLOT
  0006 CD0000     E   19          CALL    AMDCMD  ;FLOAT(NFEL)
  0009 42             20          MOV     B,D
  000A 4B             21          MOV     C,E
  000B CD0000     E   22          CALL    AMDLOD  ;DELF ↑
  000E 3E12           23          MVI     A,MULT
  0010 CD0000     E   24          CALL    AMDCMD  ;DELF*FLOAT(NFEL)
  0013 C1             25          POP     B
  0014 CD0000     E   26          CALL    AMDSTR  ;BNDW=    "
  0017 E9             27          PCHL            ;RETURN
                      28          ;
                      29          END

PUBLIC SYMBOLS
CBNDW  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    CBNDW  C 0000    FLOT   A 001D
INTLOD E 0000    MULT   A 0012

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:CCELL.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          CCELL     PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1 ;        SUBROUTINE CCELL(CELL,DIFF,SUM,ALT)
                       2 ;
                       3          NAME    CCELL
                       4 ;
                       5 ;
  00F0                 6 PORT     EQU     00F0H
  0004                 7 TAN      EQU     04H
  0011                 8 SUBT     EQU     11H
  0012                 9 MULT     EQU     12H
                      10 ;
                      11          EXTRN   AMDLOD
                      12          EXTRN   AMDSTR
                      13          EXTRN   AMDCMD
                      14 ;
                      15          PUBLIC  CCELL
                      16 ;
                      17          CSEG
                      18 ;
  0000 E1             19 CCELL:   POP     H                  ;SAVE RETURN ADDRESS
  0001 CD0000    E    20          CALL    AMDLOD             ;SUM ↑
  0004 3E04           21          MVI     A,TAN
  0006 CD0000    E    22          CALL    AMDCMD             ;TANGENT
  0009 C1             23          POP     B
  000A CD0000    E    24          CALL    AMDLOD             ;DIFF ↑
  000D 3E04           25          MVI     A,TAN
  000F CD0000    E    26          CALL    AMDCMD             ;TANGENT
  0012 3E11           27          MVI     A,SUBT
  0014 CD0000    E    28          CALL    AMDCMD             ;-
  0017 42             29          MOV     B,D
  0018 4B             30          MOV     C,E
  0019 CD0000    E    31          CALL    AMDLOD             ;ALT ↑
  001C 3E12           32          MVI     A,MULT
  001E CD0000    E    33          CALL    AMDCMD             ;X
  0021 C1             34          POP     B
  0022 CD0000    E    35          CALL    AMDSTR             ;SAVE IT IN CELL
  0025 E9             36          PCHL                       ;RETURN
                      37          END

 PUBLIC SYMBOLS
 CCELL  C 0000

 EXTERNAL SYMBOLS
 AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

 USER SYMBOLS
 AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    CCELL  C 0000    MULT   A 0012
 PORT   A 00F0    SUBT   A 0011    TAN    A 0004

 ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:CELCNT.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        CELCNT    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1          NAME     CELCNT
                      2 ;
                      3 ;
                      4 ;        SUBROUTINE CELCNT(ICNT,VEL,TC,ALT,THET8)
                      5 ;        !!! ICNT=IFIX((ALT*TAN(THET8))/(VEL*TC)+.5)
                      6 ;
  00F0                7 PORT     EQU      00F0H
  0010                8 AD       EQU      10H
  0012                9 MULT     EQU      12H
  0013               10 DIV      EQU      13H
  0004               11 TAN      EQU      04H
  001F               12 FIX      EQU      1FH
                     13 ;
                     14          EXTRN    AMDLOD
                     15          EXTRN    AMDSTR
                     16          EXTRN    AMDCMD
                     17          EXTRN    GIVE
                     18          EXTRN    INTSTR
                     19 ;
                     20          PUBLIC   CELCNT
                     21 ;
                     22          CSEG
                     23 ;
  0000 E1            24 CELCNT:  POP      H               ;SAVE RETURN ADDRESS
  0001 CD0000    E   25          CALL     AMDLOD          ;ALT ↑
  0004 42            26          MOV      B,D
  0005 4B            27          MOV      C,E
  0006 CD0000    E   28          CALL     AMDLOD          ;THET8 ↑
  0009 3E04          29          MVI      A,TAN
  000B CD0000    E   30          CALL     AMDCMD          ;TAN(THET8)
  000E 3E12          31          MVI      A,MULT
  0010 CD0000    E   32          CALL     AMDCMD          ;X
  0013 C1            33          POP      B
  0014 CD0000    E   34          CALL     AMDLOD          ;TC ↑
  0017 3E13          35          MVI      A,DIV
  0019 CD0000    E   36          CALL     AMDCMD          ;/
  001C C1            37          POP      B
  001D CD0000    E   38          CALL     AMDLOD          ;VEL ↑
  0020 3E13          39          MVI      A,DIV
  0022 CD0000    E   40          CALL     AMDCMD          ;/
  0025 113A00    C   41          LXI      D,HALF
  0028 CD0000    E   42          CALL     GIVE            ;.5 ↑
  002B 3E10          43          MVI      A,AD
  002D CD0000    E   44          CALL     AMDCMD          ;+
  0030 3E1F          45          MVI      A,FIX
  0032 CD0000    E   46          CALL     AMDCMD          ;CONVERT TO INTEGER
  0035 C1            47          POP      B
  0036 CD0000    E   48          CALL     INTSTR          ;SAVE RESULT IN ICNT
  0039 E9            49          PCHL                     ;RETURN
                     50 ;
  003A 00            51 HALF:    DB       00H,00H,80H,00H
  003B 00
  003C 80
  003D 00
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          CELCNT   PAGE    2

  LOC  OBJ         LINE        SOURCE STATEMENT
                     52          END

PUBLIC SYMBOLS
CELCNT C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GIVE   E 0000    INTSTR E 0000

USER SYMBOLS
AD     A 0010    AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    CELCNT C 0000    DIV    A 0013
   FIX    A 001F
GIVE   E 0000    HALF   C 003A    INTSTR E 0000    MULT   A 0012    PORT   A 00F0    TAN    A 0004

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:CINDX.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        CINDX    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1              NAME    CINDX
                       2 ;            SUBROUTINE CINDX(IX,I1,TWO,HALF,D)
                       3 ;
                       4 ;            !!! IX=IFIX((D+0.5)/TWO)+I1
                       5 ;
  0010                 6 AD           EQU     10H
  0013                 7 DIV          EQU     13H
  001F                 8 FIX          EQU     1FH
  006C                 9 IAD          EQU     6CH
                      10 ;
                      11 EXTRN        AMDLOD,INTLOD,INTSTR,AMDCMD
                      12 ;
                      13 PUBLIC       CINDX
                      14 ;
                      15 CSEG
                      16 ;
  0000 E1             17 CINDX:       POP     H         ;SAVE RTN ADDR
  0001 CD0000    E    18              CALL    AMDLOD    ;HALF ↑`
  0004 42             19              MOV     B,D
  0005 4B             20              MOV     C,E
  0006 CD0000    E    21              CALL    AMDLOD    ;D ↑
  0009 3E10           22              MVI     A,AD
  000B CD0000    E    23              CALL    AMDCMD    ;D+0.5
  000E C1             24              POP     B
  000F CD0000    E    25              CALL    AMDLOD    ;TWO ↑
  0012 3E13           26              MVI     A,DIV
  0014 CD0000    E    27              CALL    AMDCMD    ;(D+.5)/2.
  0017 3E1F           28              MVI     A,FIX
  0019 CD0000    E    29              CALL    AMDCMD    ;IFIX((D+.5)/2.)
  001C C1             30              POP     B
  001D CD0000    E    31              CALL    INTLOD    ;I1 ↑
  0020 3E6C           32              MVI     A,IAD
  0022 CD0000    E    33              CALL    AMDCMD    ;IFIX(...)+I1
  0025 C1             34              POP     B
  0026 CD0000    E    35              CALL    INTSTR    ;IX<--IFIX(...)+I1
  0029 E9             36              PCHL              ;RETURN
                      37 ;
                      38              END

PUBLIC SYMBOLS
CINDX  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AD     A 0010    AMDCMD E 0000    AMDLOD E 0000    CINDX  C 0000    DIV    A 0013
FIX    A 001F    IAD    A 006C    INTLOD E 0000    INTSTR E 0000

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:CLNPT.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        CLNPT    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME    CLNPT
                       2 ;
                       3 ;        SUBROUTINE CLNPT(IBPT,LT,PC,PN,XT,YI,ANGTD,ALT)
                       4 ;
                       5 ;        :::     ANGTD = ASIN(ANGTD)
                       6 ;                XT = (ALT*ALT+YI*YI)*TAN(ANGTD)**2
                       7 ;                IBPT = LT-IFIX(PC*(TAN(ANGTD)-PN))
                       8 ;
  0005                 9 ASIN     EQU     05H
  0004                10 TAN      EQU     04H
  0017                11 PUSHT    EQU     17H
  0012                12 FMUL     EQU     12H
  0010                13 FADD     EQU     10H
  0011                14 FSUB     EQU     11H
  001F                15 IFIX     EQU     1FH
  006D                16 ISUB     EQU     6DH
  0074                17 ICHS     EQU     74H
                      18 ;
                      19          EXTRN   AMDLOD,AMDSTR,AMDCMD,INTLOD,INTSTR,GIVE,GET
                      20 ;
                      21          PUBLIC  CLNPT
                      22 ;
                      23          CSEG
                      24 ;
  0000 E1             25 CLNPT:   POP     H         ;SAVE RETURN ADDRESS
  0001 C5             26          PUSH    B         ;SAVE ADDRESS OF ANGTD
  0002 CD0000    E    27          CALL    AMDLOD    ;ANGTD ↑
  0005 3E05           28          MVI     A,ASIN
  0007 CD0000    E    29          CALL    AMDCMD    ;ASIN(ANGTD):--:--:--
  000A 3E17           30          MVI     A,PUSHT
  000C CD0000    E    31          CALL    AMDCMD    ;ASIN(ANGTD):ASIN(ANGTD):--:--
  000F C1             32          POP     B
  0010 CD0000    E    33          CALL    AMDSTR    ;SAVE IN ANGTD
  0013 3E04           34          MVI     A,TAN
  0015 CD0000    E    35          CALL    AMDCMD    ;TAN(ANGTD):--:--:--
  0018 3E17           36          MVI     A,PUSHT
  001A CD0000    E    37          CALL    AMDCMD
  001D CD0000    E    38          CALL    AMDCMD    ;TAN(ANGTD):TAN(ANGTD):TAN(ANGTD):--
  0020 D5             39          PUSH    D
  0021 110000    D    40          LXI     D,HOLD
  0024 CD0000    E    41          CALL    GET       ;SAVE TAN(ANGTD) IN HOLD
  0027 3E12           42          MVI     A,FMUL
  0029 CD0000    E    43          CALL    AMDCMD    ;TAN(ANGTD)**2:--:--:--
  002C C1             44          POP     B
  002D CD0000    E    45          CALL    AMDLOD    ;ALT ↑
  0030 3E17           46          MVI     A,PUSHT
  0032 CD0000    E    47          CALL    AMDCMD
  0035 3E12           48          MVI     A,FMUL
  0037 CD0000    E    49          CALL    AMDCMD    ;ALT**2:TAN(ANGTD)**2:--:--
  003A C1             50          POP     B
  003B CD0000    E    51          CALL    AMDLOD    ;YI ↑
  003E 3E17           52          MVI     A,PUSHT
  0040 CD0000    E    53          CALL    AMDCMD
  0043 3E12           54          MVI     A,FMUL
  0045 CD0000    E    55          CALL    AMDCMD    ;YI**2:ALT**2:TAN(ANGTD)**2:--
  0048 3E10           56          MVI     A,FADD
  004A CD0000    E    57          CALL    AMDCMD    ;YI**2+ALT**2:TAN(ANGTD)**2:--:--
  004D 3E12           58          MVI     A,FMUL
  004F CD0000    E    59          CALL    AMDCMD    ;(YI**2+ALT**2)*TAN(ANGTD)**2:--:--:--
  0052 C1             60          POP     B
  0053 CD0000    E    61          CALL    AMDSTR    ;SAVE RESULT IN XT
  0056 110000    D    62          LXI     D,HOLD
  0059 CD0000    E    63          CALL    GIVE      ;TAN(ANGTD) ↑
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        CLNPT    PAGE    2

  LOC  OBJ          LINE        SOURCE STATEMENT

  005C C1             64          POP     B
  005D CD0000   E     65          CALL    AMDLOD  ;PN ↑
  0060 3E11           66          MVI     A,FSUB
  0062 CD0000   E     67          CALL    AMDCMD  ;TAN(ANGTD)-PN:--:--:--
  0065 C1             68          POP     B
  0066 CD0000   E     69          CALL    AMDLOD  ;PC ↑
  0069 3E12           70          MVI     A,FMUL
  006B CD0000   E     71          CALL    AMDCMD  ;PC*(TAN(ANGTD)-PN):--:--:--
  006E 3E1F           72          MVI     A,IFIX
  0070 CD0000   E     73          CALL    AMDCMD  ;IFIX(PC*(TAN(ANGTD)-PN)):--:--:--
  0073 C1             74          POP     B
  0074 CD0000   E     75          CALL    INTLOD  ;LT ↑
  0077 3E6D           76          MVI     A,ISUB
  0079 CD0000   E     77          CALL    AMDCMD  ;IFIX(PC*(TAN(ANGTD)-PN))-LT:--:--:--
  007C 3E74           78          MVI     A,ICHS
  007E CD0000   E     79          CALL    AMDCMD  ;LT-IFIX(PC*(TAN(ANGTD)-PN)):--:--:--
  0081 C1             80          POP     B
  0082 CD0000   E     81          CALL    INTSTR  ;SAVE RESULT IN IBPT
  0085 E9             82          PCHL            ;RETURN
                      83 ;
                      84          DSEG
                      85 ;
  0000                86 HOLD:    DS      4
                      87          END

PUBLIC SYMBOLS
CLNPT  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GET    E 0000    GIVE   E 0000
INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    ASIN   A 0005    CLNPT  C 0000
FADD   A 0010    FMUL   A 0012    FSUB   A 0011    GET    E 0000    GIVE   E 0000
HOLD   D 0000    ICHS   A 0074    IFIX   A 001F    INTLOD E 0000    INTSTR E 0000
ISUB   A 006D    PUSHT  A 0017    TAN    A 0004

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:CNFILT.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         CNFILT   PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT
                       1         NAME    CNFILT
                       2 ;
                       3 ;       SUBROUTINE CNFILT(NFEL,DEL,BNDW,CELL,FDOP,ANGLD,YI,XI,XT,S
                    LMDA,VEL,ALT)
                       4 ;
                       5 ;       :: XT=(2.*VEL)/SLMDA
                       6 ;          ANGLD=ATAN(SQRT((XI*XI)/(ALT*ALT+YI*YI)))
                       7 ;          FDOP=XT*SIN(ANGLD)
                       8 ;          BNDW=(CELL*XT/ALT)*COS(ANGLD)**3
                       9 ;          NFEL=IFIX(BNDW/DEL+0.5)
                      10 ;
  0010                11 FADD    EQU     10H
  0012                12 MULT    EQU     12H
  0013                13 FDIV    EQU     13H
  0007                14 ATAN    EQU     07H
  0001                15 SQRT    EQU     01H
  0002                16 SIN     EQU     02H
  001F                17 FIX     EQU     1FH
  0017                18 PUSHT   EQU     17H
  0003                19 COS     EQU     03H
                      20 ;
                      21 EXTRN   AMDLOD,AMDCMD,INTSTR,AMDSTR,GET,GIVE
                      22 ;
                      23 PUBLIC  CNFILT
                      24 ;
                      25 CSEG
                      26 ;
  0000 E1             27 CNFILT: POP     H         ;SAVE RTN ADDR
  0001 220000    D    28         SHLD    ISAVE     ;AT INTERNAL BUFF
  0004 62             29         MOV     H,D
  0005 6B             30         MOV     L,E       ;PUT ALT ADDR IN RP(HL)
  0006 CD0000    E    31         CALL    AMDLOD    ;VEL ↑
  0009 3E17           32         MVI     A,PUSHT
  000B CD0000    E    33         CALL    AMDCMD    ;VEL ↑
  000E 3E10           34         MVI     A,FADD
  0010 CD0000    E    35         CALL    AMDCMD    ;2.*VEL
  0013 C1             36         POP     B
  0014 CD0000    E    37         CALL    AMDLOD    ;SLMDA ↑
  0017 3E13           38         MVI     A,FDIV
  0019 CD0000    E    39         CALL    AMDCMD    ;2.*VEL/SLMDA
  001C 3E17           40         MVI     A,PUSHT
  001E CD0000    E    41         CALL    AMDCMD    ;XT:XT:-:-
  0021 C1             42         POP     B
  0022 CD0000    E    43         CALL    AMDSTR    ;SAVE XT
  0025 110200    D    44         LXI     D,ISAVE+2
  0028 CD0000    E    45         CALL    GET       ;SAVE CY OF XT
  002B C1             46         POP     B
  002C CD0000    E    47         CALL    AMDLOD    ;XI ↑
  002F 3E17           48         MVI     A,PUSHT
  0031 CD0000    E    49         CALL    AMDCMD    ;XI:XI:-:-
  0034 3E12           50         MVI     A,MULT
  0036 CD0000    E    51         CALL    AMDCMD    ;XI*XI
  0039 C1             52         POP     B
  003A CD0000    E    53         CALL    AMDLOD    ;YI ↑
  003D 3E17           54         MVI     A,PUSHT
  003F CD0000    E    55         CALL    AMDCMD    ;YI:YI:XI*XI:-
  0042 3E12           56         MVI     A,MULT
  0044 CD0000    E    57         CALL    AMDCMD    ;YI*YI:XI*XI:-:-
  0047 44             58         MOV     B,H
  0048 4D             59         MOV     C,L
  0049 CD0000    E    60         CALL    AMDLOD    ;ALT ↑
  004C 3E17           61         MVI     A,PUSHT
  004E CD0000    E    62         CALL    AMDCMD    ;ALT:ALT:-:-
```

```
 LOC  OBJ          LINE        SOURCE STATEMENT

0051 3E12            63        MVI     A,MULT
0053 CD0000     E    64        CALL    AMDCMD   ;ALT*ALT
0056 3E10            65        MVI     A,FADD
0058 CD0000     E    66        CALL    AMDCMD   ;(ALT**2)+(YI**2);
005B 3E13            67        MVI     A,FDIV
005D CD0000     E    68        CALL    AMDCMD   ;(XI**2)/(ALT**2+YI**2)
0060 3E01            69        MVI     A,SQRT
0062 CD0000     E    70        CALL    AMDCMD   ;SQRT(  "   )
0065 3E07            71        MVI     A,ATAN
0067 CD0000     E    72        CALL    AMDCMD   ;ATAN(SQRT(....))
006A 3E17            73        MVI     A,PUSHT
006C CD0000     E    74        CALL    AMDCMD   ;ATAN(..):ATAN(..)
006F C1              75        POP     B
0070 CD0000     E    76        CALL    AMDSTR   ;ANGLD=       "
0073 3E17            77        MVI     A,PUSHT
0075 CD0000     E    78        CALL    AMDCMD   ;ANGLD:ANGLD
0078 110600     D    79        LXI     D,ISAVE+6
007B CD0000     E    80        CALL    GET      ;SAVE CY OF ANGLD
007E 3E02            81        MVI     A,SIN
0080 CD0000     E    82        CALL    AMDCMD   ;SIN(ANGLD)
0083 110200     D    83        LXI     D,ISAVE+2
0086 CD0000     E    84        CALL    GIVE     ;XT:SIN(A..)
0089 3E12            85        MVI     A,MULT
008B CD0000     E    86        CALL    AMDCMD   ;XT*SIN(A..)
008E C1              87        POP     B
008F CD0000     E    88        CALL    AMDSTR   ;FDOP = "
0092 110600     D    89        LXI     D,ISAVE+6
0095 CD0000     E    90        CALL    GIVE     ;ANGLD ↑
0098 3E03            91        MVI     A,COS
009A CD0000     E    92        CALL    AMDCMD   ;COS(A..)
009D 3E17            93        MVI     A,PUSHT
009F CD0000     E    94        CALL    AMDCMD   ;COS(A..):COS(A..):-:-
00A2 3E17            95        MVI     A,PUSHT
00A4 CD0000     E    96        CALL    AMDCMD   ;COSA:COSA:COSA:-
00A7 3E12            97        MVI     A,MULT
00A9 CD0000     E    98        CALL    AMDCMD   ;COSA*COSA:COSA
00AC 3E12            99        MVI     A,MULT
00AE CD0000     E   100        CALL    AMDCMD   ;COSA**3
00B1 110200     D   101        LXI     D,ISAVE+2
00B4 CD0000     E   102        CALL    GIVE     ;XT↑
00B7 3E12           103        MVI     A,MULT
00B9 CD0000     E   104        CALL    AMDCMD   ;XT*COSA**3
00BC 44             105        MOV     B,H
00BD 4D             106        MOV     C,L
00BE CD0000     E   107        CALL    AMDLOD   ;ALT:XT*COSA**3
00C1 3E13           108        MVI     A,FDIV
00C3 CD0000     E   109        CALL    AMDCMD   ;XT*COSA**3/ALT
00C6 C1             110        POP     B
00C7 CD0000     E   111        CALL    AMDLOD   ;CELL ↑
00CA 3E12           112        MVI     A,MULT
00CC CD0000     E   113        CALL    AMDCMD   ;CELL*XT*COSA.....
00CF 3E17           114        MVI     A,PUSHT
00D1 CD0000     E   115        CALL    AMDCMD   ;BNDW:BNDW:-:-
00D4 C1             116        POP     B
00D5 CD0000     E   117        CALL    AMDSTR   ;SAVE VALUE OF BNDW
00D8 C1             118        POP     B
00D9 CD0000     E   119        CALL    AMDLOD   ;DEL ↑
00DC 3E13           120        MVI     A,FDIV
00DE CD0000     E   121        CALL    AMDCMD   ;BNDW/DEL
00E1 11F900     C   122        LXI     D,HALF
00E4 CD0000     E   123        CALL    GIVE     ;0.5 ↑
00E7 3E10           124        MVI     A,FADD
00E9 CD0000     E   125        CALL    AMDCMD   ;(BNDW/DEL+0.5)
00EC 3E1F           126        MVI     A,FIX
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          CNFILT    PAGE     3

  LOC  OBJ         LINE        SOURCE STATEMENT

  00EE CD0000   E   127          CALL     AMDCMD   ;IFIX(BNDW...)
  00F1 C1           128          POP      B
  00F2 CD0000   E   129          CALL     INTSTR   ;NFEL=     "
  00F5 2A0000   D   130          LHLD     ISAVE    ;GET RTN ADDR
  00F8 E9           131          PCHL              ;RETURN
                    132          ;
  00F9 00           133 HALF:    DB       00H,00H,80H,00H
  00FA 00
  00FB 80
  00FC 00
                    134          ;
                    135 DSEG
                    136          ;
  0000              137 ISAVE:   DS       10
                    138          ;
                    139          END

PUBLIC SYMBOLS
CNFILT C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GET    E 0000    GIVE   E 0000
INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    ATAN   A 0007    CNFILT C 0000
COS    A 0003    FADD   A 0010    FDIV   A 0013    FIX    A 001F    GET    E 0000
GIVE   E 0000    HALF   C 00F9    INTSTR E 0000    ISAVE  D 0000    MULT   A 0012
PUSHT  A 0017    SIN    A 0002    SQRT   A 0001

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:CRG4.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)

ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          CRG4      PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1         NAME    CRG4
                       2 ;
                       3 ;       SUBROUTINE CRG4(RG4,FRTY,ALT,ANGTL)
                       4 ;
                       5 ;       :: RG4=40.*ALOG10(ALT/COS(ANGTL)), WHERE FRTY=40.
                       6 ;
 0003                  7 COS     EQU     03H
 0013                  8 FDIV    EQU     13H
 0008                  9 ALOG    EQU     08H
 0012                 10 MULT    EQU     12H
                      11 ;
                      12 EXTRN   AMDLOD,AMDCMD,AMDSTR
                      13 ;
                      14 PUBLIC  CRG4
                      15 ;
                      16 CSEG    .
                      17 ;
 0000 E1              18 CRG4:   POP     H       ;SAVE RTN ADDR
 0001 CD0000    E     19         CALL    AMDLOD  ;ALT ↑
 0004 42              20         MOV     B,D
 0005 4B              21         MOV     C,E
 0006 CD0000    E     22         CALL    AMDLOD  ;ANGTL ↑
 0009 3E03            23         MVI     A,COS
 000B CD0000    E     24         CALL    AMDCMD  ;COS(ANGTL):ALT
 000E 3E13            25         MVI     A,FDIV
 0010 CD0000    E     26         CALL    AMDCMD  ;ALT/COS(ANGTL)
 0013 3E08            27         MVI     A,ALOG
 0015 CD0000    E     28         CALL    AMDCMD  ;ALOG10(ALT/COS(..))
 0018 C1              29         POP     B
 0019 CD0000    E     30         CALL    AMDLOD  ;40. ↑
 001C 3E12            31         MVI     A,MULT
 001E CD0000    E     32         CALL    AMDCMD  ;40.*ALOG10(ALT/COS(...))
 0021 C1              33         POP     B
 0022 CD0000    E     34         CALL    AMDSTR  ;RG4=      "
 0025 E9              35         PCHL            ;RETURN
                      36 ;
                      37         END

PUBLIC SYMBOLS
CRG4   C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
ALOG   A 0008    AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    COS    A 0003
CRG4   C 0000    FDIV   A 0013    MULT   A 0012

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:CZTINT.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         CZTINT   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1          NAME CZTINT
                      2 ;
                      3 ;        FUNCTION: CZT-BOARD INTERRUPT HANDLER
                      4 ;
                      5          PUBLIC  CZTINT
                      6          EXTRN   IENDI
                      7 ;
                      8          CSEG
                      9 ;
  0000 F5            10 CZTINT: PUSH    PSW       ;SAVE
  0001 C5            11          PUSH    B         ;REGISTERS
  0002 D5            12          PUSH    D         ;IN THE CURRENT
  0003 E5            13          PUSH    H         ;STATE OF THE MACHINE
  0004 CD0000   E    14          CALL    IENDI
  0007 E1            15          POP     H         ;RESTORE
  0008 D1            16          POP     D         ;REGISTERS
  0009 C1            17          POP     B         ;TO THEIR ORIG STATE
  000A 3E20          18          MVI     A,20H     ;RESTORE
  000C D3D8          19          OUT     0D8H      ;MACHINE TO OPER LEVEL
  000E 3EFF          20          MVI     A,0FFH    ;RESET INTERRUPT MASK
  0010 D3D9          21          OUT     0D9H      ;FOR NO INTERRUPTS
  0012 F1            22          POP     PSW       ;RESTORE ACCUM & FLAGS
  0013 FB            23          EI                ;ENABLE INTERRUPTS
  0014 C9            24          RET               ;RETURN
                     25          END

PUBLIC SYMBOLS
CZTINT C 0000

EXTERNAL SYMBOLS
IENDI  E 0000

USER SYMBOLS
CZTINT C 0000    IENDI  E 0000

ASSEMBLY COMPLETE,    NO ERRORS
```

c-3

```
ASM80 :F1:DAREA.SRC DEBUG PAGELENGTH(79)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          DAREA    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME    DAREA
                       2 ;
                       3 ;        SUBROUTINE DAREA(AL,TEN,TRM1,TRM2,TRM3)
                       4 ;
                       5 ;        :: AL=10.*ALOG10(TRM1*(TRM2-TRM3))
                       6 ;
  0012                 7 MULT     EQU     12H
  0008                 8 LOG      EQU     08H
  0011                 9 FSUB     EQU     11H
                      10 ;
                      11 EXTRN    AMDLOD,AMDCMD,AMDSTR
                      12 ;
                      13 PUBLIC   DAREA
                      14 ;
                      15 CSEG
                      16 ;
  0000 E1             17 DAREA:   POP     H       ;HOLD RTN ADDR
  0001 CD0000    E    18          CALL    AMDLOD  ;TRM2 ↑
  0004 42             19          MOV     B,D
  0005 4B             20          MOV     C,E
  0006 CD0000    E    21          CALL    AMDLOD  ;TRM3 ↑
  0009 3E11           22          MVI     A,FSUB
  000B CD0000    E    23          CALL    AMDCMD  ;TRM2-TRM3
  000E C1             24          POP     B
  000F CD0000    E    25          CALL    AMDLOD  ;TRM1 ↑
  0012 3E12           26          MVI     A,MULT
  0014 CD0000    E    27          CALL    AMDCMD  ;TRM1*(TRM2-TRM3)
  0017 3E08           28          MVI     A,LOG
  0019 CD0000    E    29          CALL    AMDCMD  ;ALOG10(   "    )
  001C C1             30          POP     B
  001D CD0000    E    31          CALL    AMDLOD  ;10. ↑
  0020 3E12           32          MVI     A,MULT
  0022 CD0000    E    33          CALL    AMDCMD  ;10.*ALOG10(...)
  0025 C1             34          POP     B
  0026 CD0000    E    35          CALL    AMDSTR  ;AL=    "
  0029 E9             36          PCHL            ;RETURN
                      37          ;
                      38          END

PUBLIC SYMBOLS
DAREA  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    DAREA  C 0000    FSUB   A 0011    LOG    A 0
    MULT   A 0012

ASSEMBLY COMPLETE,   NO ERRORS
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT DECODA
OBJECT MODULE PLACED IN :F1:DECODA.OBJ
COMPILER INVOKED BY:  FORT80 :F1:DECODA.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


              SUBROUTINE DECODA(IOV,NERZ,T1,PARM)
      C
      C !!! DECODES NERDAS FRAME USING AND SUBROUTINES
      C
              DIMENSION PARM(5),II(5)
              INTEGER*1 IOV(5),NERZ(60)
      C
              COMMON/GG/CL(6),CC(7,2),CST(9)
      C
      C  ======================== DECODE ALT UP TO 9999. FEET =====
      C
         10   IF(IOV(1).NE.0) GO TO 30
              DO 20 K=1,4
              II(K)=NERZ(27+K)
         20   CONTINUE
         25   CALL ALTFP(PARM(1),CST(8),II(2),II(3),II(4),II(1))
      C
      C  ======================-====  DECODE DRIFT,ROLL,PITCH UP TO 99.9 DEG
      C
        30    DO 50 J=2,4
              IF(IOV(J).NE.0) GO TO 50
              II(4)=1
         35   DO 40 K=1,3
              L=39+K+4*(J-2)
              II(K)=NERZ(L)
         40   CONTINUE
              IF(NERZ(L+1).EQ.14)II(4)=-1
              CALL DRPFP(PARM(J),CST(7),II(4),II(2),II(3),II(1))
         50   CONTINUE
      C
      C  ================  DECODE VEL UP TO 999. KNOTS  =========
      C
         60   IF(IOV(5).NE.0) GO TO 80
              DO 70 K=1,3
              II(K)=NERZ(51+K)
         70   CONTINUE
              CALL VELFP(PARM(5),CST(9),II(2),II(3),II(1))
      C
      C  ================ DECODE TIME UP TO 24*3600. SECONDS ======
      C
         80   DO 85 K=2,4
              II(K)=NERZ(K)
         85   CONTINUE
              CALL TSECS(II(1),II(3),II(4),II(2))
              IF(II(1).GT.599)II(1)=599
              II(3)=NERZ(5)
              II(4)=NERZ(6)
              CALL MINHR(II(2),II(3),II(4))
              IF(II(2).GT.59)II(2)=59
              II(4)=NERZ(7)
              II(5)=NERZ(8)
              CALL MINHR(II(3),II(4),II(5))
              IF(II(3).GT.23)II(3)=23
              CALL TIMEFP(T1,II(1),II(2),II(3))
      C
              RETURN
              END


MODULE INFORMATION:

     CODE AREA SIZE     = 0291H    657D
     VARIABLE AREA SIZE = 0018H     24D
     MAXIMUM STACK SIZE = 000AH     10D
     57 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT DECODA
```

```
      0 TOTAL PROGRAM ERROR(S)
      END OF FORTRAN COMPILATION
```

```
ASM80 :F1:DRPFP.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          DRPFP     PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                       ;       SUBROUTINE DRPFP(DRP,CRAD,ISGN,ITN,IHD,IUN)
                       ;
                               NAME     DRPFP
                       ;
                       ;       EVALUATES DRIFT,ROLL,OR PITCH IN RADIANS
                       ;
                       ;       DRP=FLOAT((IUN+10*(ITN+10*IHD))*ISGN)/CRAD
                       ;                WHERE CRAD=573.
                       ;
                       ;
  0013                         DIV      EQU      13H
  0012                         MULT     EQU      12H
  006C                         IAD      EQU      6CH
  006E                         IMULT    EQU      6EH
  001D                         FLOAT    EQU      1DH
                       ;
                               EXTRN    INTLOD,AMDCMD,AMDSTR,AMDLOD
                               PUBLIC   DRPFP
                       ;
                               CSEG
                       ;
  0000 E1                DRPFP: POP     H        ;SAVE RETURN ADDR
  0001 CD0000      E           CALL     INTLOD   ;IHD ↑
  0004 014900      C           LXI      B,TEN
  0007 CD0000      E           CALL     INTLOD   ;10 ↑
  000A 3E6E                    MVI      A,IMULT
  000C CD0000      E           CALL     AMDCMD   ;X
  000F C1                      POP      B
  0010 CD0000      E           CALL     INTLOD   ;ITN
  0013 3E6C                    MVI      A,IAD
  0015 CD0000      E           CALL     AMDCMD   ;+
  0018 014900      C           LXI      B,TEN
  001B CD0000      E           CALL     INTLOD   ;10 ↑
  001E 3E6E                    MVI      A,IMULT
  0020 CD0000      E           CALL     AMDCMD   ;X
  0023 42                      MOV      B,D
  0024 4B                      MOV      C,E
  0025 CD0000      E           CALL     INTLOD   ;IUN ↑
  0028 3E6C                    MVI      A,IAD
  002A CD0000      E           CALL     AMDCMD   ;+
  002D C1                      POP      B
  002E CD0000      E           CALL     INTLOD   ;ISGN ↑
  0031 3E6E                    MVI      A,IMULT
  0033 CD0000      E           CALL     AMDCMD   ;X
  0036 3E1D                    MVI      A,FLOAT
  0038 CD0000      E           CALL     AMDCMD   ;FLOAT
  003B C1                      POP      B
  003C CD0000      E           CALL     AMDLOD   ;CRAD
  003F 3E13                    MVI      A,DIV
  0041 CD0000      E           CALL     AMDCMD   ;/
  0044 C1                      POP      B
  0045 CD0000      E           CALL     AMDSTR   ;SAVE RESULT IN DRP
  0048 E9                      PCHL              ;RETURN
  0049 0A00              TEN:  DW       10
                               END

 PUBLIC SYMBOLS
 DRPFP  C 0000

 EXTERNAL SYMBOLS
 AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000
```

```
USER SYMBOLS
ANDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    DIV    A 0013    DRPFP  C 0000
FLOAT  A 001D    IAD    A 006C    IMULT  A 006E    INTLOD E 0000    MULT   A 0012
TEN    C 0049

ASSEMBLY COMPLETE,   NO ERRORS
```

```
  LOC  OBJ                      SOURCE STATEMENT

  003F C31000    C                JMP     STPO      ;  ELSE REPLACE THE CHAR WITH '0'
                        ;
  0042 0C               CP2:      INR     C         ;ADD 2 TO THE
  0043 0C                         INR     C         ;       REGISTER C TO SET
  0044 C34800    C                JMP     CP1+1     ;             THE UNARY FLAG
                        ;
  0047 0C               CP1:      INR     C         ;SET DECIMAL FLAG BY ADDING 1 TO C(C)
  0048 FE2B                       CPI     02BH      ;CHECK FOR PLUS SIGN
  004A CA1000    C                JZ      STPO
  004D C31200    C                JMP     STP       ;CONTINUE
                        ;
  0050 79               CO:       MOV     A,C       ;CHECK DECIMAL FLAG
  0051 FE00                       CPI     00H       ;     FOR ZERO, IF NOT
  0053 CA4200    C                JZ      CP2       ;       SET, THEN DO IT
  0056 C31200    C                JMP     STP       ;ELSE GO TO GET THE NEXT BYTE
                        ;
                                  END

PUBLIC SYMBOLS
ASCDV  C 0000

EXTERNAL SYMBOLS


USER SYMBOLS
ASCDV  C 0000    CO      C 0050    CCO    C 002A    CPO    C 0039    CP1    C 0047    CP2    C 0042
   DC      C 0018
GC     C 0005    STP     C 0012    STPO   C 0010

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:DVERIF.SRC DEBUG XREF


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        DVERIF   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1              NAME DVERIF
                      2 ;
                      3              CSEG
                      4 ;
                      5              PUBLIC ASCDV
                      6 ;
                      7 ;     FUNCTION:
                      8 ;          EDITS A BUFFER FOR 'F' FORMAT INPUT DATA.  LEADING
                      9 ;          '+' OR '-' UNARIES ARE ACCEPTED, BUT OTHERS ARE
                     10 ;          CONVERTED TO BLANK.  ONLY THE FIRST '.' IS ACCEPTED,
                     11 ;          ALL OTHER NON-DIGIT CHARACTERS ARE CONVERTED TO ZERO.
                     12 ;          LEADING '+' IS REPLACED WITH BLANK.  LEADING '-' UNCHANGED.
                     13 ;
                     14 ;     REGITERS UPON ENTRY:
                     15 ;          C(BC)=ADDR OF CHAR COUNT IN BUFFER
                     16 ;          C(DE)=ADDR OF BUFFER CONTAINING THE CHAR STRING
                     17 ;
                     18 ;     REGISTERS ALTERED:
                     19 ;          C(HL), C(DE), C(A), C(B), C(C)
                     20 ;
  0000 EB            21 ASCDV:   XCHG                ;SET BUFFER POINTER
  0001 0A            22          LDAX     B          ;GET BYTE COUNT
  0002 0E00          23          MVI      C,00H      ;SET C(C)=0
  0004 47            24          MOV      B,A        ;SET BYTE COUNT REGISTER
  0005 7E            25 GC:      MOV      A,M        ;GET A BYTE FROM MEMORY
  0006 FE30          26          CPI      030H       ;CHECK FOR CHAR < '0'
  0008 DA1800   C    27          JC       DC         ;IF YES , CHECK FOR A '.'
  000B FE3A          28          CPI      03AH       ;ELSE CHECK FOR < ':', THEN VERIFY
  000D DA5000   C    29          JC       CO         ;        THAT THE UNARY FLAG IS SET
  0010 3620          30 STPO:    MVI      M,020H     ;ELSE REPLACE CHAR WITH BLANK
  0012 23            31 STP:     INX      H          ;STEP BUFFER POINTER
  0013 05            32          DCR      B          ;   AND DECREMENT BYTE COUNT
  0014 C20500   C    33          JNZ      GC         ;IF NOT LAST BYTE, GO GET NEXT
  0017 C9            34          RET                 ;        RETURN WHEN DONE....
                     35 ;
  0018 FE2E          36 DC:      CPI      02EH       ;CHECK FOR '.'
  001A CA2A00   C    37          JZ       CCO        ;IF CHAR IS '.', CHECK FOR DECIMAL FLAG SET
  001D FE2D          38          CPI      02DH       ;    CHECK FOR '-' FIRST
  001F CA3900   C    39          JZ       CPO        ;IF CHAR IS '-', CHECK DECIMAL FLAG
  0022 FE2B          40          CPI      02BH       ;             FOR A '+' CAROT
  0024 CA3900   C    41          JZ       CPO        ;IF '+' , CHECK DECIMAL FLAG SET
  0027 C31000   C    42          JMP      STPO       ;IF NOT SET, REPLACE THE CHAR WITH '0'
                     43 ;
  002A 79            44 CCO:     MOV      A,C        ;CHECK THE DECIMAL FLAG
  002B FE00          45          CPI      00H        ;    TO SEE IF IT IS SET
  002D CA4700   C    46          JZ       CP1        ;IF NOT SET, SET IT
  0030 79            47          MOV      A,C        ;IF SET, CHECK THE UNARY FLAG
  0031 FE02          48          CPI      02H        ;IF UNARY FLAG IS SET, THEN
  0033 CA4700   C    49          JZ       CP1        ;          SET THE DECIMAL FLAG
  0036 C31000   C    50          JMP      STPO       ;  ELSE REPLACE THE CHAR WITH '0'
                     51 ;
  0039 79            52 CPO:     MOV      A,C        ;CHECK DECIMAL FLAG
  003A FE00          53          CPI      00H        ;IF FLAG IS NOT SET,
  003C CA4200   C    54          JZ       CP2        ;      THEN SET THE UNARY FLAG
```

```
                         NAME     FDLEV
                ;
                ;         SUBROUTINE FDLEV(IFDL,NFEL,NEV,FDOP,DELF)
                ;
                ;        ;;; IFDL=IFIX(FDOP/DELF)+NEV-NFEL/2
                ;
0013            FDIV     EQU      13H
001F            FIX      EQU      1FH
006C            IAD      EQU      6CH
006F            IDIV     EQU      6FH
006D            ISUB     EQU      6DH
                ;
                EXTRN    AMDLOD,AMDCMD,INTLOD,INTSTR
                ;
                PUBLIC   FDLEV
                ;
                CSEG
                ;
0000 E1         FDLEV:   POP      H         ;PICK OF RTN ADDR
0001 CD0000   E          CALL     AMDLOD    ;FDOP ↑
0004 42                  MOV      B,D
0005 4B                  MOV      C,E
0006 CD0000   E          CALL     AMDLOD    ;DELF ↑
0009 3E13                MVI      A,FDIV
000B CD0000   E          CALL     AMDCMD    ;(FDOP/DELF)
000E 3E1F                MVI      A,FIX
0010 CD0000   E          CALL     AMDCMD    ;IFIX(...)
0013 C1                  POP      B
0014 CD0000   E          CALL     INTLOD    ;NEV ↑
0017 3E6C                MVI      A,IAD
0019 CD0000   E          CALL     AMDCMD    ;IFIX(...)+NEV
001C C1                  POP      B
001D CD0000   E          CALL     INTLOD    ;NFEL ↑
0020 013500   C          LXI      B,TWO
0023 CD0000   E          CALL     INTLOD    ;2 ↑
0026 3E6F                MVI      A,IDIV
0028 CD0000   E          CALL     AMDCMD    ;(NFEL/2)
002B 3E6D                MVI      A,ISUB
002D CD0000   E          CALL     AMDCMD    ;(IFIX(...)+NEV-(NFEL/2)
0030 C1                  POP      B
0031 CD0000   E          CALL     INTSTR    ;IFDL=
0034 E9                  PCHL               ;RETURN
                         ;
0035 0200       TWO:     DW       2
                         ;
                         END

PUBLIC SYMBOLS
FDLEV  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    FDIV   A 0013    FDLEV  C 0000    FIX    A 001F
IAD    A 006C    IDIV   A 006F    INTLOD E 0000    INTSTR E 0000    ISUB   A 006D
TWO    C 0035

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:FDLOD.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          FDLOD    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1          NAME    FDLOD
                      2 ;
                      3 ;        SUBROUTINE FDLOD(IFDL,NFEL,NOD,FDCP,DELF)
                      4 ;
                      5 ;        ::: IFDL=IFIX(FDOP/DELF+0.5)+NOD-(NFEL-1)/2
                      6 ;
  0013                7 FDIV     EQU     13H
  0010                8 FADD     EQU     10H
  001F                9 FIX      EQU     1FH
  006C               10 IAD      EQU     6CH
  006D               11 ISUB     EQU     6DH
  006F               12 IDIV     EQU     6FH
                     13 ;
                     14 EXTRN AMDLOD,AMDCMD,INTLOD,INTSTR,GIVE
                     15 ;
                     16 PUBLIC FDLOD
                     17 ;
                     18 CSEG
                     19 ;
  0000 E1            20 FDLOD:   POP     H         ;PULL RTN ADDR OFF STK
  0001 CD0000    E   21          CALL    AMDLOD    ;FDOP ↑
  0004 42            22          MOV     B,D
  0005 4B            23          MOV     C,E
  0006 CD0000    E   24          CALL    AMDLOD    ;DELF ↑
  0009 3E13          25          MVI     A,FDIV
  000B CD0000    E   26          CALL    AMDCMD    ;FDOP/DELF
  000E 114B00    C   27          LXI     D,HALF
  0011 CD0000    E   28          CALL    GIVE      ;0.5 ↑
  0014 3E10          29          MVI     A,FADD
  0016 CD0000    E   30          CALL    AMDCMD    ;(FDOP/DELF)+.5
  0019 3E1F          31          MVI     A,FIX
  001B CD0000    E   32          CALL    AMDCMD    ;IFIX(F/D+.5)
  001E C1            33          POP     B
  001F CD0000    E   34          CALL    INTLOD    ;NOD ↑
  0022 3E6C          35          MVI     A,IAD
  0024 CD0000    E   36          CALL    AMDCMD    ;IFIX(...)+NOD
  0027 C1            37          POP     B
  0028 CD0000    E   38          CALL    INTLOD    ;NFEL ↑
  002B 014F00    C   39          LXI     B,ONE
  002E CD0000    E   40          CALL    INTLOD    ;ONE ↑
  0031 3E6D          41          MVI     A,ISUB
  0033 CD0000    E   42          CALL    AMDCMD    ;(NFEL-1)
  0036 015100    C   43          LXI     B,TWO
  0039 CD0000    E   44          CALL    INTLOD    ;2 ↑
  003C 3E6F          45          MVI     A,IDIV
  003E CD0000    E   46          CALL    AMDCMD    ;(...)/2
  0041 3E6D          47          MVI     A,ISUB
  0043 CD0000    E   48          CALL    AMDCMD    ;IFIX(...)-(...)/2
  0046 C1            49          POP     B
  0047 CD0000    E   50          CALL    INTSTR    ;IFDL=   "
  004A E9            51          PCHL              ;RETURN
                     52          ;
  004B 00            53 HALF:    DB      00H,00H,80H,00H
  004C 00
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         FDLOD    PAGE    2

  LOC  OBJ         LINE        SOURCE STATEMENT

  004D 80
  004E 00
  004F 0100          54 ONE:    DW      1
  0051 0200          55 TWO:    DW      2
                     56         ;
                     57         END

PUBLIC SYMBOLS
FDLOD  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    GIVE   E 0000    INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    FADD   A 0010    FDIV   A 0013    FDLOD  C 0000    FIX    A 001F
   GIVE   E 0000
HALF   C 004B    IAD    A 006C    IDIV   A 006F    INTLOD E 0000    INTSTR E 0000    ISUB   A 0068
   ONE    C 004F
TWO    C 0051

ASSEMBLY COMPLETE,   NO ERRORS
```

```
FORTRAN COMPILER
              PAGE    1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT GAIN
OBJECT MODULE PLACED IN :F1:GAIN.OBJ
COMPILER INVOKED BY:  FORT80 :F1:GAIN.SRC DEBUG PAGELENGTH(77)


                  SUBROUTINE GAIN(ANG,PCH,IGTBL,IGTBC,NPZN,IBND,GSQ)
                  INTEGER*2 IGTBL(80,4),IGTBC(31,4)
         C
         C        !!! L-BAND TABLES !!!
         C TABLE FOR EACH FREQ/POLARIZ COMBO, 80 VALUES IN EACH,
         C  ORDERED FOR ANGLES FROM -70 TO +10 DEGREES
         C  INPUT ANG & PCH IN RADIANS
         C
                  COMMON/GG/CL(6),CC(7,2),CST(9)
         C
                  CALL AMDSUB(AGL,ANG,PCH)
                  GO TO (5,10),IBND
             5    IN=80
                  CALL AINDX(INDX,IN,CST(4),AGL,CST(3))
                  IF(INDX.LE.0)INDX=1
                  IF(INDX.GE.81)INDX=IN
                  CALL AFLOAT(IGTBL(INDX,NPZN),GSQ)
                  CALL AMDIV(GSQ,GSQ,CST(4))
                  RETURN
         C
         C***  C-BAND PATTERN ***
         C
         C        TABLE FOR EACH FREQ/POLZ COMBO, 31 VALUES IN EACH,
         C          ORDERED FOR ANGLES FROM 0 TO -60 DEGREES
         C
            10    CALL AMDMUL(D,AGL,CST(3))
                  D=ABS(D)
                  IN=1
                  CALL CINDX(INDX,IN,CST(2),CST(6),D)
                  IF(INDX.GE.31)GO TO 15
                  IF(INDX.LE.0)INDX=1
                  CALL AFLOAT(INDX,DG)
                  CALL AMDMUL(DG,DG,CST(2))
                  CALL AMDSUB(DG,DG,CST(2))
                  CALL AMDSUB(DG,D,DG)
                  CALL AMDGN(DGN,CST(2),DG,CST(4),IGTBC(INDX+1,NPZN),IGTBC(INDX,NPZN))
                  CALL AMDGSQ(GSQ,DGN,IGTBC(INDX,NPZN),CST(4))
                  RETURN
            15    CALL AFLOAT(IGTBC(31,NPZN),GSQ)
                  CALL AMDIV(GSQ,GSQ,CST(4))
                  RETURN
         C
                  END


MODULE INFORMATION:

     CODE AREA SIZE      = 01DCH    476D
     VARIABLE AREA SIZE = 0022H     34D
     MAXIMUM STACK SIZE = 000CH     12D
     43 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT GAIN

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
ASM80 :F1:GAMC.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(70)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GAMC      PAGE    1

  LOC  OBJ          LINE         SOURCE STATEMENT

                       1           NAME     GAMC
                       2 ;         SUBROUTINE GAMC(Z,C1,C2,C3,C4,C5,C6,C7,F)
                       3 ;
                       4 ;
                       5 ;         ;;;  Z=C1+F*(C2+F*(C3+F*(C4+C5*F)))+(C6+C7/F)/F
                       6 ;              Z=-Z
                       7 ;
  0010                 8 FADD      EQU      10H
  0011                 9 SUBT      EQU      11H
  0012                10 MULT      EQU      12H
  0013                11 FDIV      EQU      13H
  0015                12 FCHS      EQU      15H
                      13 ;
                      14 EXTRN     AMDLOD,AMDCMD,AMDSTR
                      15 ;
                      16 PUBLIC    GAMC
                      17 ;
                      18 CSEG
                      19 ;
  0000 E1             20 GAMC:     POP      H         ;PICK OFF RETURN ADDR
  0001 220000   D     21           SHLD     ISAVE     ;SAVE IT
  0004 62             22           MOV      H,D
  0005 6B             23           MOV      L,E       ;SAVE F ADDR IN RP(HL)
  0006 CD0000   E     24           CALL     AMDLOD    ;C7 ↑
  0009 42             25           MOV      B,D
  000A 4B             26           MOV      C,E
  000B CD0000   E     27           CALL     AMDLOD    ;F ↑
  000E 3E13           28           MVI      A,FDIV
  0010 CD0000   E     29           CALL     AMDCMD    ;C7/F
  0013 C1             30           POP      B
  0014 CD0000   E     31           CALL     AMDLOD    ;C6 ↑
  0017 3E10           32           MVI      A,FADD
  0019 CD0000   E     33           CALL     AMDCMD    ;(C6+C7/F)
  001C 44             34           MOV      B,H
  001D 4D             35           MOV      C,L
  001E CD0000   E     36           CALL     AMDLOD    ;F ↑
  0021 3E13           37           MVI      A,FDIV
  0023 CD0000   E     38           CALL     AMDCMD    ;( ... )/F
  0026 C1             39           POP      B
  0027 CD0000   E     40           CALL     AMDLOD    ;C5 ↑
  002A 44             41           MOV      B,H
  002B 4D             42           MOV      C,L
  002C CD0000   E     43           CALL     AMDLOD    ;F ↑
  002F 3E12           44           MVI      A,MULT
  0031 CD0000   E     45           CALL     AMDCMD    ;C5*F
  0034 C1             46           POP      B
  0035 CD0000   E     47           CALL     AMDLOD    ;C4 ↑
  0038 3E10           48           MVI      A,FADD
  003A CD0000   E     49           CALL     AMDCMD    ;(C4+C5*F)
  003D 44             50           MOV      B,H
  003E 4D             51           MOV      C,L
  003F CD0000   E     52           CALL     AMDLOD    ;F ↑
  0042 3E12           53           MVI      A,MULT
  0044 CD0000   E     54           CALL     AMDCMD    ;( ... )*F
  0047 C1             55           POP      B
  0048 CD0000   E     56           CALL     AMDLOD    ;C3 ↑
  004B 3E10           57           MVI      A,FADD
  004D CD0000   E     58           CALL     AMDCMD    ;C3+( ... )*F
  0050 44             59           MOV      B,H
  0051 4D             60           MOV      C,L
  0052 CD0000   E     61           CALL     AMDLOD    ;F ↑
  0055 3E12           62           MVI      A,MULT
  0057 CD0000   E     63           CALL     AMDCMD    ;F*(C3+F*( ... ))
  005A C1             64           POP      B
  005B CD0000   E     65           CALL     AMDLOD    ;C2 ↑
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GAMC     PAGE    2

  LOC  OBJ          LINE        SOURCE STATEMENT

  005E 3E10           66          MVI     A,FADD
  0060 CD0000    E    67          CALL    AMDCMD    ;C2+F*(C3+F*( ... ))
  0063 44             68          MOV     B,H
  0064 4D             69          MOV     C,L
  0065 CD0000    E    70          CALL    AMDLOD    ;F ↑
  0068 3E12           71          MVI     A,MULT
  006A CD0000    E    72          CALL    AMDCMD    ;F*(C2+F*( ...)))
  006D C1             73          POP     B
  006E CD0000    E    74          CALL    AMDLOD    ;C1 ↑
  0071 3E10           75          MVI     A,FADD
  0073 CD0000    E    76          CALL    AMDCMD    ;C1+F*(C2+F*( ... )))
  0076 3E10           77          MVI     A,FADD
  0078 CD0000    E    78          CALL    AMDCMD    ;C1+F*(C2+F*(...)))+(C6+...)/F
  007B 3E15           79          MVI     A,FCHS
  007D CD0000    E    80          CALL    AMDCMD    ;Z=-Z
  0080 C1             81          POP     B
  0081 CD0000    E    82          CALL    AMDSTR    ;SAVE RESULT AT Z
  0084 2A0000    D    83          LHLD    ISAVE
  0087 E9             84          PCHL              ;RETURN
                      85 ;
                      86 DSEG
                      87 ;
  0000                88 ISAVE:   DS      2
                      89 ;
                      90          END

PUBLIC SYMBOLS
GAMC   C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000     AMDLOD E 0000     AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000     AMDLOD E 0000     AMDSTR E 0000     FADD    A 0010     FCHS    A 0015
FDIV   A 0013     GAMC   C 0000     ISAVE  D 0000     MULT    A 0012     SUBT    A 0011

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:GAML.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GAML      PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1         NAME    GAML
                       2 ;       SUBROUTINE GAML(Z,C1,C4,C5,C2,F,C3)
                       3 ;
                       4 ;       ;;; Z=-(C1+F*(C2+C3*F)+(C4+C5/F)/F)
                       5 ;
  0012                 6 MULT    EQU     12H
  0011                 7 SUBT    EQU     11H
  0010                 8 FADD    EQU     10H
  0015                 9 FCHS    EQU     15H
  0013                10 FDIV    EQU     13H
  0017                11 PUSHT   EQU     17H
                      12 ;
                      13 EXTRN   AMDCMD,AMDSTR,AMDLOD
                      14 ;
                      15 PUBLIC  GAML
                      16 ;
                      17 CSEG
                      18 ;
  0000 E1             19 GAML:   POP     H       ;SAVE RETURN ADDR
  0001 220000   D     20         SHLD    ISAVE   ;AT INTERNAL BUFFER
  0004 60             21         MOV     H,B
  0005 69             22         MOV     L,C     ;SAVE ADDR OF F IN RP(HL)
  0006 CD0000   E     23         CALL    AMDLOD  ;F ↑
  0009 3E17           24         MVI     A,PUSHT
  000B CD0000   E     25         CALL    AMDCMD  ;F ↑
  000E 42             26         MOV     B,D
  000F 4B             27         MOV     C,E
  0010 CD0000   E     28         CALL    AMDLOD  ;C3 ↑
  0013 3E12           29         MVI     A,MULT
  0015 CD0000   E     30         CALL    AMDCMD  ;C3*F:F
  0018 C1             31         POP     B
  0019 CD0000   E     32         CALL    AMDLOD  ;C2 ↑
  001C 3E10           33         MVI     A,FADD
  001E CD0000   E     34         CALL    AMDCMD  ;(C2+C3*F):F
  0021 3E12           35         MVI     A,MULT
  0023 CD0000   E     36         CALL    AMDCMD  ;(C2+C3*F)*F
  0026 010200   D     37         LXI     B,ISAVE+2
  0029 CD0000   E     38         CALL    AMDSTR  ;SAVE RESULT AT INTERNAL BUFFER
  002C C1             39         POP     B
  002D CD0000   E     40         CALL    AMDLOD  ;C5 ↑
  0030 44             41         MOV     B,H
  0031 4D             42         MOV     C,L
  0032 CD0000   E     43         CALL    AMDLOD  ;F ↑
  0035 3E13           44         MVI     A,FDIV
  0037 CD0000   E     45         CALL    AMDCMD  ;C5/F
  003A C1             46         POP     B
  003B CD0000   E     47         CALL    AMDLOD  ;C4 ↑
  003E 3E10           48         MVI     A,FADD
  0040 CD0000   E     49         CALL    AMDCMD  ;(C4+C5/F)
  0043 44             50         MOV     B,H
  0044 4D             51         MOV     C,L
  0045 CD0000   E     52         CALL    AMDLOD  ;F ↑
  0048 3E13           53         MVI     A,FDIV
  004A CD0000   E     54         CALL    AMDCMD  ;( ... )/F
  004D 010200   D     55         LXI     B,ISAVE+2
  0050 CD0000   E     56         CALL    AMDLOD  ;(C2+C3*F)*F ↑
  0053 3E10           57         MVI     A,FADD
  0055 CD0000   E     58         CALL    AMDCMD  ;( ... )/F + ( ... )*F
  0058 C1             59         POP     B
  0059 CD0000   E     60         CALL    AMDLOD  ;C1 ↑
  005C 3E10           61         MVI     A,FADD
  005E CD0000   E     62         CALL    AMDCMD  ; +
  0061 3E15           63         MVI     A,FCHS
  0063 CD0000   E     64         CALL    AMDCMD  ;Z=-Z
  0066 C1             65         POP     B
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GAML     PAGE    2

  LOC  OBJ         LINE        SOURCE STATEMENT

  0067 CD0000   E    66          CALL    AMDSTR   ;SAVE RESULT AT Z
  006A 2A0000   D    67          LHLD    ISAVE
  006D E9            68          PCHL             ;RETURN
                     69 ;
                     70 DSEG
                     71 ;
  0000               72 ISAVE:   DS      6
                     73          END

PUBLIC SYMBOLS
GAML   C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    FADD   A 0010    FCHS   A 0015
FDIV   A 0013    GAML   C 0000    ISAVE  D 0000    MULT   A 0012    PUSHT  A 0017
SUBT   A 0011

ASSEMBLY COMPLETE,   NO ERRORS
```

```
FORTRAN COMPILER
                PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT GAMMA
OBJECT MODULE PLACED IN :F1:GAMMA.OBJ
COMPILER INVOKED BY:  FORT80 :F1:GAMMA.SRC DEBUG


                SUBROUTINE GAMMA(FRQ,IB,NPZ,Z)
      C
      C  !!!  EVALUATES ROLL-OFF FOR FREQUENCY,BAND,POLARIZATION COMBOS
      C
                COMMON/GG/CL(6),CC(7,2),CST(9)
      C
                CALL AMDIV(F,FRQ,CL(6))
                GO TO(10,15),IP
      C
      C !!! L-BAND DATA !!'
         10     CALL GAML(Z,CL(1),CL(4),CL(5),CL(2),F,CL(3))
                RETURN
      C
      C !!! C-BAND DATA !!!
         15     GO TO (17,17,16,16),NPZ
      C  !!!      NPZ: 1=VV,2=VH,3=HH,4=HV
      C
         16     CALL GAMC(Z,CC(1,2),CC(2,2),CC(3,2),CC(4,2),CC(5,2),CC(6,2),CC(7,2),F)
                RETURN
         17     CALL GAMC(Z,CC(1,1),CC(2,1),CC(3,1),CC(4,1),CC(5,1),CC(6,1),CC(7,1),F)
                RETURN
                END

MODULE INFORMATION:

     CODE AREA SIZE      = 00B1H     177D
     VARIABLE AREA SIZE  = 000CH      12D
     MAXIMUM STACK SIZE  = 0010H      16D
     22 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT GAMMA

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
FORTRAN COMPILER
            PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT GETVLU
OBJECT MODULE PLACED IN :F1:GETVLU.OBJ
COMPILER INVOKED BY:  FORT80 :F1:GETVLU.SRC DEBUG SYMBOLS PAGELENGTH(53)


            SUBROUTINE GETVLU(CIOBUF,IOBUFF,N10,N20,ISTAT,IERR,XNUM)
            EXTERNAL MSGOUT,KEYBRD,ASCDV,CRLF
            INTEGER*1 IOBUFF(30),N10,N20
            CHARACTER*30 CIOBUF
   C
            CALL CRLF
            IERR=0
        5   WRITE(CIOBUF,10,IOSTAT=ISTAT,ERR=50)
       10   FORMAT(5X,'ENTER VALUE:',13X)
       15   CALL MSGOUT(N20,IOBUFF)
       20   CALL KEYBRD(N10,IOBUFF)
       25   CALL ASCDV(N10,IOBUFF)
       30   READ(CIOBUF,35,IOSTAT=ISTAT,ERR=51,END=52) XNUM
       35   FORMAT(F5.0)
       40   RETURN
   C
       50   IERR=1
            GO TO 40
       51   IERR=2
            GO TO 40
       52   IERR=3
            GO TO 40
   C
            END
```

```
FORTRAN COMPILER
               PAGE   2

SYMBOL LISTING
--------------

   DEFN  ADDR  SIZE  NAME, ATTRIBUTES, AND REFERENCES
   ----  ----  ----  --------------------------------

      8 0000H        10           LABEL
      9 008CH        15           LABEL
     10 0098H        20           LABEL
     11 00A4H        25           LABEL
     12 00B0H        30           LABEL
     13 0017H        35           LABEL
     14 00FAH        40           LABEL
      7 0053H        5            LABEL
     15 00FBH        50           LABEL
     17 0107H        51           LABEL
     19 0113H        52           LABEL
        0010H    18  @IOPB        INTEGER*2 DIMENSIONED
                     ASCDV        EXTERNAL SUBROUTINE
        0000H     2  CIOBUF       CHARACTER*30 PARAMETER
        0002H     2  CIOBUF@      INTEGER*2
                     CRLF         EXTERNAL SUBROUTINE
        000CH     2  IERR         INTEGER*2 PARAMETER
        0004H     2  IOBUFF       INTEGER*1 PARAMETER DIMENSIONED
        000AH     2  ISTAT        INTEGER*2 PARAMETER
                     KEYBRD       EXTERNAL SUBROUTINE
                     MSGOUT       EXTERNAL SUBROUTINE
```

```
FORTRAN COMPILER
            PAGE   3

        0006H     2  N10           INTEGER*1 PARAMETER

        0008H     2  N20           INTEGER*1 PARAMETER

        000EH     2  XNUM          REAL*4 PARAMETER


MODULE INFORMATION:

     CODE AREA SIZE     = 011FH    287D
     VARIABLE AREA SIZE = 0022H     34D
     MAXIMUM STACK SIZE = 000CH     12D
     24 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT GETVLU

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
ASM80 :F1:GXI.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GXI      PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT
                     1          NAME    GXI
                     2 ;
                     3 ;        SUBROUTINE GXI(XI,XT,ALT,RL,DR)
                     4 ;        ::: XI=XT*COS(DR)+ALT*TAN(RL)*SIN(DR)
                     5 ;
  0003               6 COS      EQU     03H
  0002               7 SIN      EQU     02H
  0012               8 MULT     EQU     12H
  0004               9 TAN      EQU     04H
  0010              10 FADD     EQU     10H
  0019              11 EXCHG    EQU     19H
                    12 ;
                    13 EXTRN AMDLOD,AMDCMD,AMDSTR
                    14 ;
                    15 PUBLIC  GXI
                    16 ;
                    17 CSEG
                    18 ;
  0000 E1           19 GXI:     POP     H         ;SAVE RTN ADDR
  0001 CD0000   E   20          CALL    AMDLOD    ;RL ↑
  0004 3E04         21          MVI     A,TAN
  0006 CD0000   E   22          CALL    AMDCMD    ;TAN(RL)
  0009 42           23          MOV     B,D
  000A 4B           24          MOV     C,E
  000B CD0000   E   25          CALL    AMDLOD    ;DR ↑
  000E 3E02         26          MVI     A,SIN
  0010 CD0000   E   27          CALL    AMDCMD    ;SIN(DR)
  0013 3E12         28          MVI     A,MULT
  0015 CD0000   E   29          CALL    AMDCMD    ;SIND*TANR
  0018 C1           30          POP     B
  0019 CD0000   E   31          CALL    AMDLOD    ;ALT:SIND*TANR
  001C 3E12         32          MVI     A,MULT
  001E CD0000   E   33          CALL    AMDCMD    ;ALT*SIND*TANR
  0021 42           34          MOV     B,D
  0022 4B           35          MOV     C,E
  0023 CD0000   E   36          CALL    AMDLOD    ;DR ↑
  0026 3E03         37          MVI     A,COS
  0028 CD0000   E   38          CALL    AMDCMD    ;COS(DR)
  002B C1           39          POP     B
  002C CD0000   E   40          CALL    AMDLOD    ;XT ↑
  002F 3E12         41          MVI     A,MULT
  0031 CD0000   E   42          CALL    AMDCMD    ;XT*COS(DR):ALT*...:--:--
  0034 3E10         43          MVI     A,FADD
  0036 CD0000   E   44          CALL    AMDCMD    ;(XT...)+(ALT*SD*TR)
  0039 C1           45          POP     B
  003A CD0000   E   46          CALL    AMDSTR    ;XI =       "
  003D E9           47          PCHL              ;RETURN
                    48          ;
                    49          END

PUBLIC SYMBOLS
GXI    C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    COS     A 0003    EXCHG   A 0019
FADD   A 0010    GXI    C 0000    MULT   A 0012    SIN     A 0002    TAN     A 0004

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:GXT.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        GXT      PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                                 NAME    GXT
                           ;
                           ;     SUBROUTINE GXT(XT,RL,ANGL,ALT)
                           ;     ::: XT=SQRT((ALT*TAN(ANGL))**2-(ALT*TAN(RL))**2)
                           ;
  0004                     TAN   EQU     04H
  0012                     MULT  EQU     12H
  0017                     PUSHT EQU     17H
  0011                     FSUB  EQU     11H
  0001                     SQRT  EQU     01H
                           ;
                           EXTRN AMDLOD,AMDCMD,AMDSTR
                           ;
                           PUBLIC GXT
                           ;
                           CSEG
                           ;
  0000 E1                  GXT:  POP     H         ;PICK OF RTN ADDR
  0001 CD0000      E             CALL    AMDLOD    ;ANGL ↑
  0004 3E04                      MVI     A,TAN
  0006 CD0000      E             CALL    AMDCMD    ;TAN(ANGL)
  0009 42                        MOV     B,D
  000A 4B                        MOV     C,E
  000B CD0000      E             CALL    AMDLOD    ;ALT ↑
  000E 3E12                      MVI     A,MULT
  0010 CD0000      E             CALL    AMDCMD    ;ALT*TAN(ANGL)
  0013 3E17                      MVI     A,PUSHT
  0015 CD0000      E             CALL    AMDCMD    ;(ATA):(ATA)
  0018 3E12                      MVI     A,MULT
  001A CD0000      E             CALL    AMDCMD    ;(ATA)**2
  001D C1                        POP     B
  001E CD0000      E             CALL    AMDLOD    ;RL ↑
  0021 3E04                      MVI     A,TAN
  0023 CD0000      E             CALL    AMDCMD    ;TAN(RL):(..**2)
  0026 42                        MOV     B,D
  0027 4B                        MOV     C,E
  0028 CD0000      E             CALL    AMDLOD    ;ALT ↑
  002B 3E12                      MVI     A,MULT
  002D CD0000      E             CALL    AMDCMD    ;ALT*TANR:(..**2)
  0030 3E17                      MVI     A,PUSHT
  0032 CD0000      E             CALL    AMDCMD    ;ATR:ATR:( ..**2)
  0035 3E12                      MVI     A,MULT
  0037 CD0000      E             CALL    AMDCMD    ;ATR**2:( ..**2)
  003A 3E11                      MVI     A,FSUB
  003C CD0000      E             CALL    AMDCMD    ;ATA**2 - ATR**2
  003F 3E01                      MVI     A,SQRT
  0041 CD0000      E             CALL    AMDCMD    ;SQRT(   "    )
  0044 C1                        POP     B
  0045 CD0000      E             CALL    AMDSTR    ;XT =    "
  0048 E9                        PCHL              ;RETURN
                                 ;
                                 END
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GXT       PAGE    2

PUBLIC SYMBOLS
GXT    C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLUD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    FSUB   A 0011    GXT    C 0000    MULT   A 0012
   PUSHT  A 0017
SQRT   A 0001    TAN    A 0004

ASSEMBLY COMPLETE,   NO ERRORS
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
ASM80 :F1:GYI.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(9[illegible])


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.[illegible]          GY[illegible]       PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                        1          NAME    GYI
                        2 ;
                        3 ;        SUBROUTINE GYI(YI,XT,ALT,RL,DR)
                        4 ;        !!! YI=XT*SIN(DR)-ALT*TAN(RL)*COS(DR)
                        5 ;
  0003                  6 COS      EQU     03H
  0002                  7 SIN      EQU     02H
  0012                  8 MULT     EQU     12H
  0004                  9 TAN      EQU     04H
  0011                 10 FSUB     EQU     11H
  0019                 11 EXCHG    EQU     19H
                       12 ;
                       13 EXTRN AMDLOD,AMDCMD,AMDSTR
                       14 ;
                       15 PUBLIC   GYI
                       16 ;
                       17 CSEG
                       18 ;
  0000 E1              19 GYI:     POP     H         ;SAVE RTN ADDR
  0001 CD0000     E    20          CALL    AMDLOD    ;RL ↑
  0004 3E04            21          MVI     A,TAN
  0006 CD0000     E    22          CALL    AMDCMD    ;TAN(RL)
  0009 42              23          MOV     B,D
  000A 4B              24          MOV     C,E
  000B CD0000     E    25          CALL    AMDLOD    ;DR ↑
  000E 3E03            26          MVI     A,COS
  0010 CD0000     E    27          CALL    AMDCMD    ;COS(DR)
  0013 3E12            28          MVI     A,MULT
  0015 CD0000     E    29          CALL    AMDCMD    ;COSD*TANR
  0018 C1              30          POP     B
  0019 CD0000     E    31          CALL    AMDLOD    ;ALT:COSD*TANR
  001C 3E12            32          MVI     A,MULT
  001E CD0000     E    33          CALL    AMDCMD    ;ALT*COSD*TANR
  0021 42              34          MOV     B,D
  0022 4B              35          MOV     C,E
  0023 CD0000     E    36          CALL    AMDLOD    ;DR ↑
  0026 3E02            37          MVI     A,SIN
  0028 CD0000     E    38          CALL    AMDCMD    ;SIN(DR)
  002B C1              39          POP     B
  002C CD0000     E    40          CALL    AMDLOD    ;XT ↑
  002F 3E12            41          MVI     A,MULT
  0031 CD0000     E    42          CALL    AMDCMD    ;XT*SIN(DR)
  0034 3E19            43          MVI     A,EXCHG
  0036 CD0000     E    44          CALL    AMDCMD    ;ALT*SD*TR:XT*SIN(DR):--:--
  0039 3E11            45          MVI     A,FSUB
  003B CD0000     E    46          CALL    AMDCMD    ;(XT...)-(ALT*SD*TR)
  003E C1              47          POP     B
  003F CD0000     E    48          CALL    AMDSTR    ;YI =       "
  0042 E9              49          PCHL              ;RETURN
                       50          ;
                       51          END

PUBLIC SYMBOLS
GYI    C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    COS     A 0003    EXCHG  A 0019
FSUB   A 0011    GYI    C 0000    MULT   A 0012    SIN     A 0002    TAN    A 0004

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:IBELL.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        IBELL    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT
                      1          NAME    IBELL
                      2 ;
                      3 ;        FUNCTION: SENDS A BELL CHARACTER TO THE CRT
                      4 ;
                      5          EXTRN   ECHO
                      6 ;
                      7          CSEG
                      8 ;
                      9          PUBLIC  IBELL
                     10 ;
  0000 0E07          11 IBELL:   MVI     C,07H    ;GET BELL CHARACTER
  0002 CD0000   E    12          CALL    ECHO     ;SEND IT TO CRT
  0005 C9            13          RET
                     14          END

PUBLIC SYMBOLS
IBELL  C 0000

EXTERNAL SYMBOLS
ECHO   E 0000

USER SYMBOLS
ECHO   E 0000    IBELL  C 0000

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:IBFILL.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          IBFILL   PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                      1           NAME IBFILL
                      2 ;
                      3 ;         FUNCTION:       FILL IOUT BUFFER WITH 099H.
                      4 ;                         EACH LINE IS 128 BYTES.
                      5 ;                         LINE COUNT PASSED IN RP(BC).
                      6 ;                         LINE COUNT IS LESS THAN 256.
                      7 ;
                      8 ;                         BUFFER ADDR PASSED IN RP(DE).
                      9 ;
                     10           CSEG
                     11 ;
                     12           PUBLIC IBFILL
                     13 ;
  0000 EB            14 IBFILL: XCHG
  0001 0A            15         LDAX     B        ;GET LINE COUNT IN ACCUM
  0002 47            16         MOV      B,A      ;SET B=LINE COUNT
  0003 0E80          17 LL1:    MVI      C,080H   ;SET COUNTER FOR BYTES PER LINE
  0005 3699          18 LL2:    MVI      M,099H   ;MOVE BYTE OF 99H TO MEMORY
  0007 23            19         INX      H        ;STEP ADDR POINTER
  0008 0D            20         DCR      C        ;DECREASE BYTE COUNT REMAINING
  0009 C20500    C   21         JNZ      LL2      ;LOOP TILL A LINE IS DONE
  000C 05            22         DCR      B        ;DECREASE LINE COUNT BY ONE
  000D C20300    C   23         JNZ      LL1      ;LOOP TIL ALL LINES DONE
  0010 C9            24         RET
                     25 ;
                     26           END

 PUBLIC SYMBOLS
 IBFILL C 0000

 EXTERNAL SYMBOLS


 USER SYMBOLS
 IBFILL C 0000    LL1    C 0003    LL2    C 0005

 ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:ICRLF.SRC DEBUG

ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        ICRLF    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1          NAME    ICRLF
                      2 ;
                      3 ;        FUNCTION IS TO OUTPUT A CARRIAGE-RETURN AND LINE FEED
                      4 ;
                      5 ;        REGISTERS ALTERED:  C(C),C(B),C(A)
                      6 ;
                      7          CSEG
                      8          PUBLIC CRLF,ECHO,CO,DELAY
                      9 ;
  00E4               10 PORTA    EQU     0E4H
  00E6               11 PORTC    EQU     0E6H
  001B               12 ESC      EQU     01BH     ;ESCAPE CHARACTER
  000D               13 CR       EQU     0DH      ;CARRIAGE RETURN CHARACTER
  000A               14 LF       EQU     0AH      ;LINE FEED CHARACTER
                     15 ;
  0000 0E0D          16 CRLF:    MVI     C,0DH    ;PUT C/R RETURN CHAR INTO REG C
  0002 CD0600    C   17          CALL    ECHO     ;SEND TO OUTPUT UNIT
  0005 C9            18          RET
                     19 ;
  0006 41            20 ECHO:    MOV     B,C      ;SAVE ARG
  0007 3E1B          21          MVI     A,ESC    ;
  0009 B8            22          CMP     B        ;ARE WE ECHOING AN ESCAPE?
  000A C20F00    C   23          JNZ     ECH05    ;IF NO , BRANCH
  000D 0E24          24          MVI     C,'$'    ;IF YES, SEND OUT A '$'
  000F CD2800    C   25 ECH05:   CALL    CO       ;DO OUTPUT THROUGH CO ROUTINE
  0012 CD4100    C   26          CALL    BUSY     ;OUT TO PRINTER
  0015 3E0D          27          MVI     A,CR     ;
  0017 B8            28          CMP     B        ;WAS CHAR = CR
  0018 C22600    C   29          JNZ     ECH10    ;IF NO , CONTINUE
  001B 0E0A          30          MVI     C,LF     ;IF YES, SEND OUT A LINE FEED ALSO
  001D CD2800    C   31          CALL    CO       ;
  0020 CD4100    C   32          CALL    BUSY     ;OUT TO PRINTER
  0023 CD3300    C   33          CALL    DELAY    ;WAIT FOR CARRIAGE TO GET HOME
  0026 48            34 ECH10:   MOV     C,B      ;RESTORE ARG
  0027 C9            35          RET
                     36 ;
  0028 DBCD          37 CO:      IN      0CDH     ;GET STATUS OF CONSOLE
  002A E601          38          ANI     01H      ;SEE IF XMTR READY
  002C CA2800    C   39          JZ      CO       ;NO - TRY AGAIN
  002F 79            40          MOV     A,C      ;ELSE MOVE CHAR TO A FOR OUTPUT
  0030 D3CC          41          OUT     0CCH     ;SEND TO CONSOLE
  0032 C9            42          RET
                     43 ;
                     44 ;
  0033 3E16          45 DELAY:   MVI     A,16H    ;SET REG A TO 16H
  0035 0E16          46          MVI     C,16H    ; "   "  C  "  "
  0037 3D            47 LOOP:    DCR     A
  0038 00            48          NOP
  0039 C23700    C   49          JNZ     LOOP
  003C 0D            50          DCR     C
  003D C23700    C   51          JNZ     LOOP
  0040 C9            52          RET
                     53 ;
  0041 DBE6          54 BUSY:    IN      PORTC    ;GET STATUS
  LOC  OBJ          LINE        SOURCE STATEMENT

  0043 E630           55          ANI      30H       ;MASK LOWER NIB,UNUSED UPPER BITS
  0045 320000    D    56          STA      LOC       ;SAVE STATUS
  0048 FE00           57          CPI      00H       ;CHECK FOR SWITCH +BUSY,LOW TRUE
  004A CA5E00    C    58          JZ       PRINT     ;IF TRUE PRINT
  004D E620           59          ANI      20H       ;MASK OFF BUSY
  004F FE00           60          CPI      00H       ;CHECK FOR TRUE
  0051 C26D00    C    61          JNZ      INCRMT
  0054 3A0000    D    62          LDA      LOC       ;RECALL STATUS BYTE
  0057 E610           63          ANI      10H       ;MASK OFF SWITCH STATUS
  0059 FE00           64          CPI      00H       ;CHECK FOR BUSY
  005B C24100    C    65          JNZ      BUSY
  005E 7E             66 PRINT:   MOV      A,M
  005F 2F             67          CMA                ;GET BYTE AND COMPLIMENT
  0060 D3E4           68          OUT      PORTA     ;SEND OUT
  0062 3E00           69          MVI      A,00H     ;SEND
  0064 D3E6           70          OUT      PORTC     ;    STROBE
  0066 00             71          NOP                ;THEN
  0067 00             72          NOP                ;    DELAY
  0068 00             73          NOP                ;           A LITTLE
  0069 3E01           74          MVI      A,01H     ;SEND HIGH TO PRINTER
  006B D3E6           75          OUT      PORTC
  006D C9             76 INCRMT:  RET
                      77 ;
                      78 DSEG
                      79 ;
  0000                80 LOC:     DS       1
                      81          END

PUBLIC SYMBOLS
CO     C 0028    CRLF    C 0000    DELAY  C 0033    ECHO    C 0006

EXTERNAL SYMBOLS

USER SYMBOLS
BUSY   C 0041    CO      C 0028    CR     A 000D    CRLF    C 0000    DELAY  C 0033    ECH05  C 0C
   ECH10   C 0026
ECHO   C 0006    ESC     A 001B    INCRMT C 006D    LF      A 000A    LOC    D 0000    LOOP   C 00
   PORTA   A 00E4
PORTC  A 00E6    PRINT   C 005E

ASSEMBLY COMPLETE,   NO ERRORS
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
FORTRAN COMPILER                                                                    PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT IENDI
OBJECT MODULE PLACED IN :F1:IENDI.OBJ
COMPILER INVOKED BY:  FORT80 :F1:IENDI.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


                      SUBROUTINE IENDI
         C
                      INTEGER*1 KESC
                      INTEGER*2 IEOC
         C
         C !!! SETS FLAG  WHEN CZI-INTEGRATION IS DONE
         C
         C
                      COMMON/A/ IEOC,KESC
         C
                      SAVE/A/
         C
                      IEOC=2
                      RETURN
                      END

MODULE INFORMATION:

      CODE AREA SIZE     = 0007H      7D
      VARIABLE AREA SIZE = 0000H      0D
      MAXIMUM STACK SIZE = 0000H      0D
      15 LINES READ

      0 PROGRAM ERROR(S) IN PROGRAM UNIT IENDI

      0 TOTAL PROGRAM ERROR(S)
      END OF FORTRAN COMPILATION
```

```
ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT IKEYI
OBJECT MODULE PLACED IN :F1:IKEYI.OBJ
COMPILER INVOKED BY:   FORT80 :F1:IKEYI.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


    1                 SUBROUTINE IKEYI
    2                  INTEGER*1 KESC
              C
              C !!! SETS FLAG FOR KEYBOARD 'ESC' INTERRUPT
              C
    3                  COMMON/A/IEOC,KESC
              C
    4                  SAVE/A/
              C
    5                  KESC=2
    6                  RETURN
    7                  END

 MODULE INFORMATION:

       CODE AREA SIZE     = 0006H      6D
       VARIABLE AREA SIZE = 0000H      0D
       MAXIMUM STACK SIZE = 0000H      0D
       12 LINES READ

       0 PROGRAM ERROR(S) IN PROGRAM UNIT IKEYI

       0 TOTAL PROGRAM ERROR(S)
       END OF FORTRAN COMPILATION
```

```
ASM80 :F1:INIT.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          INIT      PAGE     1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1
                       2 ;************************************************************
                         ****
                       3 ;                    INITIALIZATION AND CZT BOARD
                       4 ;                    UTILITY ROUTINES.  ROUTINES
                       5 ;                    INCLUDED ARE:
                       6 ;                    INIPIO
                       7 ;                    INICZT
                       8 ;                    INI259
                       9 ;                    MSKSET
                      10 ;                    INTSET
                      11 ;                    NERD
                      12 ;                    CZT
                      13 ;                    CZTR
                      14 ;                    IBIPHL
                      15 ;************************************************************
                         ****
                      16 ;
                      17 ;
                      18             NAME INIT
                      19             PUBLIC  INIPIO,INICZT,INI259,MSKSET,INTSET,NERD,CZT,CZTR,I
                         BIPHL
                      20             PUBLIC  BPLISR
                      21             CSEG
                      22 ;
                      23 ;
  001F                24 ICW1     EQU     01FH
  0040                25 ICW2     EQU     40H
  0020                26 OCW2     EQU     20H
  0009                27 DMA      EQU     09H
  00A6                28 CW8255   EQU     0A6H
  00EB                29 C8255    EQU     0EBH
  000D                30 INTEA    EQU     0DH
  0005                31 INTEB    EQU     05H
  0009                32 FILB     EQU     09H
  00DD                33 FILD     EQU     0DDH
  00E8                34 D8255    EQU     0E8H
  00E9                35 DATA     EQU     0E9H
  0008                36 DATB     EQU     08H
  000A                37 LSB      EQU     0AH
  000B                38 MSB      EQU     0BH
  00FD                39 UMASK    EQU     0FDH
  00FF                40 MASK     EQU     0FFH
  00EC                41 D8251    EQU     0ECH
  0020                42 EOI      EQU     20H
  0008                43 LOADN    EQU     08H
  00EF                44 UNSYN    EQU     0EFH
  00E7                45 UNSTB    EQU     0E7H
                      46 ;
                      47 ;
                      48 ;***** INITIALIZE 8255 PIO FOR BI-PHASE-L OUTPUT, NERDAS INPUT ***
                         ********
                      49 INIPIO:
  0000 3EA6           50             MVI A,  CW8255   ;CONTROL WORD FOR: PORT A MODE 1 OUTPUT
  0002 D3EB           51             OUT C8255        ;PORT B MODE 1 INPUT.  GROUP 2 SBC 80/20 B
                         OARD
  0004 3E0D           52             MVI A,  INTEA    ;ENABLE INTERRUPT UPON ACKNOWLEDGE
  0006 D3EB           53             OUT C8255        ;FOR PORT A.
  0008 3E05           54             MVI A,  INTEB    ;ENABLE INTERRUPT UPON STROBE
  000A D3EB           55             OUT C8255        ;FOR PORT B
  000C 3E09           56             MVI A,  FILB     ;SET BIT 4 OF PORT C
  000E D3EB           57             OUT C8255        ;TO INDICATE FILL DATA
  0010 3EDD           58             MVI A,  FILD     ;WRITE FILL DATA TO PORT A
  0012 D3E8           59             OUT D8255        ;FILL DATA NOW LOADED
  0014 3E08           60             MVI A,  DATB     ;RESET BIT 4 OF PORT C.  ALL DATA
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          INIT      PAGE    2

  LOC  OBJ         LINE        SOURCE STATEMENT

  0016 D3EB          61           OUT C8255         ;DATA NOW WRITTEN TO PORT A IS INTERPRETED AS R
                        EAL DATA
  0018 C9            62           RET               ;RETURN FROM INIPIO
                     63 ;
                     64 ;
                     65 ;
                     66 ;;********* INITIALIZE CZT BOARD **********
                     67 INICZT:
  0019 79            68           MOV     A,C       ;PUT IPSI(LSB) INTO ACCUM
  001A D30A          69           OUT LSB           ;OUTPUT LSB OF DMA ADDRESS
  001C 78            70           MOV     A,B       ;MOVE IPSI(MSB) TO ACCUM
  001D D30B          71           OUT MSB           ;OUTPUT MSB OF DMA ADDRESS
  001F C9            72           RET               ;RETURN FROM INICZT
                     73 ;
                     74 ;
                     75 ;
                     76 ;****************** INITIALIZE INTERRUPT CONTROLLER ***********
                        *
                     77 INI259:
  0020 F3            78           DI                ;DISABLE 8080 INTERRUPTS
  0021 3E1F          79           MVI A,  ICW1      ;SET NESTED MODE INTERRUPTS
  0023 D3D8          80           OUT 0D8H          ;CALL TABLE 4 BYTES APART
  0025 3E40          81           MVI A,  ICW2      ;SET CALL TABLE AT 4000H
  0027 D3D9          82           OUT 0D9H          ;
  0029 3EFF          83           MVI A,  MASK      ;MASK ALL INTERRUPTS
  002B D3D9          84           OUT 0D9H          ;BEFORE LEAVING INI259
  002D FB            85           EI                ;REENABLE 8080 INTERRUPTS
  002E C9            86           RET               ;RETURN FROM INI259
                     87 ;
                     88 ;
                     89 ;
                     90 ;****************** MASK SET ROUTINE *************************
                     91 MSKSET:
  002F 0A            92           LDAX B            ;MOVE IMSK TO ACCUM
  0030 D3D9          93           OUT 0D9H          ;OUTPUT TO 8259
  0032 C9            94           RET               ;RETURN FROM MSKSET
                     95 ;
                     96 ;
                     97 ;
                     98 ;*********** MASK ALL INTERRUPTS ROUTINE ***************
                     99 INTSET:
  0033 0A           100           LDAX B            ;PUT INCI INTO ACCUM
  0034 FE01         101           CPI 01H           ;SEE IF INCI IS A 1
  0036 C23B00   C   102           JNZ DSABLE        ;IF NOT JUMP
  0039 FB           103           EI                ;IF A 1 ENABLE INTERRUPT
  003A C9           104           RET               ;AND RETURN FROM INTSET
  003B F3           105 DSABLE:   DI                ;IF NOT A 1 DISABLE INTERRUPTS
  003C C9           106           RET               ;AND RETURN FROM INTSET
                    107 ;
                    108 ;
                    109 ;
                    110 ;**************** BEGIN INTEGRATION ROUTINE ****************
                    111 CZT:
  003D 0A           112           LDAX B            ;MOVE N INTO ACCUM
  003E D308         113           OUT LOADN         ;OUTPUT NUMBER OF RECORDS AND BEGIN INTEGR
                        ATION
  0040 C9           114           RET               ;RETURN FROM CZT
                    115 ;
                    116 ;
                    117 ;
                    118 ;****************** DMA TRANSFER ROUTINE **********************
                    119 CZTR:
  0041 D309         120           OUT DMA           ;START DMA TRANSFER
  0043 C9           121           RET               ;RETURN FROM CZTR
                    122 ;
                    123 ;
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
 LOC  OBJ          LINE        SOURCE STATEMENT

                    124 ;
                    125 ;****************** BI-PHASE-L OUTPUT ROUTINE ********************;
                    126 IBIPHL:
0044 1680           127             MVI D,  80H        ;SET BYTE COUNT TO 128
0046 0A             128 LOAD:       LDAX B             ;GET BYTE FROM DATA BUFFER
0047 0F             129             RRC                ;SWAP NIBBLES
0048 0F             130             RRC
0049 0F             131             RRC
004A 0F             132             RRC
004B D3E8           133             OUT D8255          ;WRITE DATA TO 8255
004D 76             134             HLT                ;WAIT FOR ACKNOWLEDGE
004E 03             135 BPLISR:     INX B              ;INCREMENT DATA BUFFER POINTER
004F 3E20           136             MVI A,  EOI        ;SEND NON-SPECIFIC END OF INTERRUPT
0051 D3D8           137             OUT 0D8H           ;TO 8259 INTERRUPT CONTROLLER
0053 FB             138             EI                 ;REENABLE 8080 INTERRUPT
0054 15             139             DCR D              ;DECREMENT BYTE COUNT
0055 C24600    C    140             JNZ LOAD           ;OUTPUT MORE DATA IF NOT DONE
0058 C9             141             RET                ;RETURN FROM INTERRUPT SERVICE ROUTINE
                    142 ;
                    143 ;
                    144 ;
                    145 ;******************* NERDAS INPUT ROUTINE *************************
                    146 NERD:
0059 0A             147             LDAX B             ;GET ICNT
005A 0F             148             RRC                ;DIVIDE ICNT BY 2 TO CHANGE TO BYTE COUNT
005B E67F           149             ANI 7FH            ;STRIP OFF MSB
005D 47             150             MOV B,A            ;PUT ICNT IN B
005E 3EEF           151             MVI A,  UNSYN      ;UNMASK SYNC INTERRUPT
0060 D3D9           152             OUT 0D9H           ;
0062 76             153             HLT                ;WAIT FOR SYNC
0063 FB             154             EI                 ;REENABLE 8080 INTERRUPTS
0064 3EE7           155             MVI A,  UNSTB      ;UNMASK STROBE INTERRUPT
0066 D3D9           156             OUT 0D9H           ;
0068 76             157 STB:        HLT                ;WAIT FOR STROBE INTERRUPT
0069 FB             158             EI                 ;REENABLE 8080 INTERRUPT UPON RETURN
006A DBE9           159             IN DATA            ;GET A BYTE OF DATA
006C 0F             160             RRC                ;SWAP
006D 0F             161             RRC                ;     NIBBLES
006E 0F             162             RRC                ;             IN EACH
006F 0F             163             RRC                ;                    BYTE
0070 12             164             STAX D             ;STORE IN IOBUF
0071 13             165             INX D              ;INCREMENT IOBUF POINTER
0072 05             166             DCR B              ;DECREMENT ICNT
0073 CA7D00    C    167             JZ FNSH            ;JUMP IF ICNT = 0
0076 3E20           168             MVI A,  EOI        ;SEND END OF INTERRUPT
0078 D3D8           169             OUT 0D8H           ;(LEVEL 3)
007A C36800    C    170             JMP STB            ;GET MORE DATA
007D 3E20           171 FNSH:       MVI A,  EOI        ;SEND END OF INTERRUPT
007F D3D8           172             OUT 0D8H           ;(LEVEL 3) STROBE INTERRUPT
0081 D3D8           173             OUT 0D8H           ;(LEVEL 4) SYNC INTERRUPT
0083 3EFF           174             MVI A,  MASK       ;MASK ALL INTERRUPTS BEFORE RETURNING
0085 D3D9           175             OUT 0D9H           ;
0087 C9             176             RET                ;RETURN FROM NERD
                    177 ;
                    178 ;
                    179 ;
                    180 ;************************************************************
                        ****
                    181 ;                 END OF UTILITY AND INITIALIZATION ROUTINES
                    182 ;************************************************************
                        *****
                    183             END

PUBLIC SYMBOLS
BPLISR C 004E    CZT    C 003D    CZTR   C 0041    IBIPHL C 0044    INI259 C 0020
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          INIT     PAGE    4

INICZT C 0019    INIPID C 0000    INTSET C 0033    MSKSET C 002F    NERI   C 0057
EXTERNAL SYMBOLS

USER SYMBOLS
EPLISR C 004E    C8255  A 00EB    CW8253 A 00A6    CZT    C 003E    CZTR   C 0041
D8251  A 00EC    D8255  A 00E8    DATA   A 00E7    DATE   A 0005    IMA    A 0007
DSABLE C 003E    EOI    A 0020    FILE   A 0007    FILE   A 0020    FRSH   C 007E
DBIPHL C 0044    ICW1   A 001F    ICW2   A 0040    INT257 C 0020    INICZT C 0019
INIPID C 0000    INTEA  A 0002    INTEB  A 0003    INTSET C 0033    LOAD   C 0046
LOADR  A 0003    LSB    A 000A    MASK   A 00FF    MSB    A 0002    MSKSET C 002F
NERI   C 0057    OCW2   A 0020    STB    C 0063    UMASK  A 00FE    UNSIG  A 00E7
UNSYN  A 00EF

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:INTGT.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          INTGT     PAGE     1

  LOC  OBJ          LINE         SOURCE STATEMENT
                       1           NAME    INTGT
                       2   ;
                       3   ;       SUBROUTINE INTGT(ICNT,TI,DELF)
                       4   ;
                       5   ;       ;;; ICNT=IFIX(TI*DELF+0.5)
                       6   ;
  0010                 7   FADD    EQU     10H
  0012                 8   MULT    EQU     12H
  001F                 9   FIX     EQU     1FH
                      10   ;
                      11   EXTRN AMDLOD,AMDCMD,INTSTR,GIVE
                      12   ;
                      13   PUBLIC  INTGT
                      14   ;
                      15   CSEG
                      16   ;
  0000 E1             17   INTGT:  POP     H       ;SAVE RTN ADDR
  0001 CD0000    E    18           CALL    AMDLOD  ;TI ↑
  0004 42             19           MOV     B,D
  0005 4B             20           MOV     C,E
  0006 CD0000    E    21           CALL    AMDLOD  ;DELF ↑
  0009 3E12           22           MVI     A,MULT
  000B CD0000    E    23           CALL    AMDCMD  ;TI*DELF
  000E 112300    C    24           LXI     D,HALF
  0011 CD0000    E    25           CALL    GIVE    ;0.5 ↑
  0014 3E10           26           MVI     A,FADD
  0016 CD0000    E    27           CALL    AMDCMD  ;TI*DELF + .5
  0019 3E1F           28           MVI     A,FIX
  001B CD0000    E    29           CALL    AMDCMD  ;IFIX(TI*DELF+.5)
  001E C1             30           POP     B
  001F CD0000    E    31           CALL    INTSTR  ;ICNT=    "
  0022 E9             32           PCHL            ;RETURN
                      33           ;
  0023 00             34   HALF:   DB      00H,00H,80H,00H
  0024 00
  0025 80
  0026 00
                      35           ;
                      36           END

PUBLIC SYMBOLS
INTGT  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    GIVE   E 0000    INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    FADD   A 0010    FIX    A 001F    GIVE   E 0000    HALF   C 0023
   INTGT  C 0000
INTSTR E 0000    MULT   A 0012

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:IUSART.SRC DEBUG SYMBOLS XREF

ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        IUSART   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT
                     1          NAME IUSART
                     2 ;
                     3 ;        FUNCTION IS TO INITIALIZE THE PROTOTYPE USART
                     4 ;
                     5 ;        REGISTERS ALTERED:  C(A)
                     6 ;
                     7          CSEG
                     8          PUBLIC  IUSRT
                     9 ;
  00CE              10          MODE    EQU     0CEH
  00CD              11          CNCTL   EQU     0CDH
  0027              12          CMD     EQU     027H
                    13 ;
  0000 3ECE         14 IUSRT:   MVI     A,MODE   ;GET MODE SETTING
  0002 D3CD         15          OUT     CNCTL    ;OUT-PUT IT TO THE USART
  0004 3E27         16          MVI     A,CMD    ;GET CMD
  0006 D3CD         17          OUT     CNCTL    ;    AND SEND IT OUT
  0008 C9           18          RET
                    19 ;
                    20          END

PUBLIC SYMBOLS
IUSRT  C 0000

EXTERNAL SYMBOLS

USER SYMBOLS
CMD    A 0027    CNCTL  A 00CD    IUSRT  C 0000    MODE   A 00CE

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80  :F1:I32SUM.SRC DEBUG PAGELENGTH(75)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          I32SUM    PAGE    1

  LOC  OBJ          LINE         SOURCE STATEMENT

                       1          NAME    I32SUM
                       2 ;
                       3 ;        SUBROUTINE I32SUM(PX,NV,IV)
                       4 ;
                       5 ;        :: PX=10.*ALOG10(FLOAT(NV(1)+NV(2)+ ... +NV(IV)))
                       6 ;
                       7 ;
  0008                 8 LOG      EQU     08H
  0012                 9 MULT     EQU     12H
  001C                10 FLOT32   EQU     1CH
  002C                11 IADD32   EQU     2CH
                      12 ;
                      13          EXTRN   I32LOD,AMDCMD,AMDSTR,GIVE
                      14 ;
                      15          PUBLIC  I32SUM
                      16 ;
                      17          CSEG
                      18 ;
  0000 E1             19 I32SUM:  POP     H                 ;SAVE RETURN ADDRESS
  0001 1A             20          LDAX    D                 ;GET    COUNT
  0002 57             21          MOV     D,A               ;PUT IN D
  0003 CD0000    E    22          CALL    I32LOD            ;LOAD FIRST ENTRY
  0006 15             23 LOOP:    DCR     D                 ;IF LAST ENTRY GO TO FLOAT
  0007 CA1500    C    24          JZ      FLOAT
  000A CD0000    E    25          CALL    I32LOD            ;SUM IN NEXT ENTRY
  000D 3E2C           26          MVI     A,IADD32
  000F CD0000    E    27          CALL    AMDCMD
  0012 C30600    C    28          JMP     LOOP
  0015 3E1C           29 FLOAT:   MVI     A,FLOT32
  0017 CD0000    E    30          CALL    AMDCMD            ;FLOAT RESULT
  001A 3E08           31          MVI     A,LOG
  001C CD0000    E    32          CALL    AMDCMD            ;ALOG10(SUM)
  001F 112F00    C    33          LXI     D,TEN
  0022 CD0000    E    34          CALL    GIVE              ;10. ↑
  0025 3E12           35          MVI     A,MULT
  0027 CD0000    E    36          CALL    AMDCMD            ;10.*ALOG10(SUM)
  002A C1             37          POP     B
  002B CD0000    E    38          CALL    AMDSTR            ;SAVE IN PX
  002E E9             39          PCHL                      ;RETURN
                      40          ;
  002F 00             41 TEN:     DB      00H,00H,0A0H,04H
  0030 00
  0031 A0
  0032 04
                      42          ;
                      43          END

 PUBLIC SYMBOLS
 I32SUM C 0000

 EXTERNAL SYMBOLS
 AMDCMD E 0000    AMDSTR E 0000    GIVE   E 0000    I32LOD E 0000

 USER SYMBOLS
 AMDCMD E 0000    AMDSTR E 0000    FLOAT  C 0015    FLOT32 A 001C    GIVE   E 0000    I32LOD E 0000
    I32SUM C 0000
 IADD32 A 002C    LOG    A 0008    LOOP   C 0006    MULT   A 0012    TEN    C 002F

 ASSEMBLY COMPLETE,   NO ERRORS
```

```
FORTRAN COMPILER                                                          PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT KBPHAL
OBJECT MODULE PLACED IN :F1:KBPHAL.OBJ
COMPILER INVOKED BY:  FORT80 :F1:KBPHAL.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


    1             SUBROUTINE KBPHAL(IOUT)
            C
            C   ******   HANDLES BI-PHASE-L OUTPUTS   *********
            C
    2             INTEGER*1 IOUT(128)
            C
            C  :: SET MASK TO ALLOW LEVEL 1 INTERRUPTS ::
    3             J=#0FDH
    4             CALL MSKSET(J)
            C  ::  WRITE LINE TO BI-PHASE-L INTERFACE  ::
    5             CALL IBIPHL(IOUT)
            C  ::  SET MASK TO MASK ALL INTERRUPTS  ::
    6             J=#0FFH
    7             CALL MSKSET(J)
            C ::  BACK-FILL BUFFER LINE JUST WRITTEN WITH #099H  ::
    8             DO 10 J=1,128
    9             IOUT(J)=#099H
   10         10  CONTINUE
   11             RETURN
   12             END


MODULE INFORMATION:

     CODE AREA SIZE     = 004EH     78D
     VARIABLE AREA SIZE = 0004H      4D
     MAXIMUM STACK SIZE = 0002H      2D
     20 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT KBPHAL

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
ASM80 :F1:KEYCHK.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         KEYCHK    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1          NAME    KEYCHK
                      2 ;
                      3 ;        FUNCTION: SENSES KEYBOARD FOR AN ESCAPE CHARACTER.  IF NO
                      4 ;                  CHARACTER IS PENDING OR IF PENDING CHARACTER IS NOT
                      5 ;                  AN 'ESC', THEN NO ACTION IS TAKEN.  IF 'ESC' IS FOUND
                      6 ;                  A BRANCH TO 'IKEYI' IS TAKEN TO SET THE MAIN PROGRAM
                      7 ;                  FLAG 'KESC'.
                      8 ;
                      9          PUBLIC  KEYCHK
                     10 ;
                     11          EXTRN   ECHO,IKEYI
                     12 ;
                     13          CSEG
                     14 ;
  0000 DBCD          15 KEYCHK:  IN      0CDH      ;GET STATUS OF CONSOLE
  0002 E602          16          ANI     02H       ;RCVR READY?
  0004 CA1C00    C   17          JZ      XIT       ;NO,THEN EXIT
  0007 DBCC          18          IN      0CCH      ;YES, GET CHARACTER
  0009 E67F          19          ANI     07FH      ;STRIP PARITY
  000B FE1B          20          CPI     01BH      ;IS IT 'ESC' ?
  000D C21C00    C   21          JNZ     XIT       ;NO, THEN IGNORE
  0010 4F            22          MOV     C,A       ;YES,SAVE VALUE
  0011 CD0000    E   23          CALL    ECHO      ;AND ECHO TO SCREEN
  0014 CD0000    E   24          CALL    IKEYI     ;SET KEY INTERRUPT FLAG
  0017 0E07          25          MVI     C,07H     ;GET BELL CHARACTER
  0019 CD0000    E   26          CALL    ECHO      ;SEND IT OUT
  001C C9            27 XIT:     RET
                     28          ;
                     29          END

PUBLIC SYMBOLS
KEYCHK C 0000

EXTERNAL SYMBOLS
ECHO    E 0000    IKEYI   E 0000

USER SYMBOLS
ECHO    E 0000    IKEYI   E 0000    KEYCHK C 0000    XIT    C 001C

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:KEYIN.SRC DEBUG PAGELENGTH(77)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          KEYIN     PAGE    1

 LOC  OBJ          LINE        SOURCE STATEMENT

                     1           NAME KEYIN
                     2 ;
                     3           PUBLIC  KEYBRD,GETCH,CI
                     4 ;
                     5           CSEG
                     6 ;
                     7           EXTRN   ECHO
0008                 8 BACK      EQU     08H        ;HEX VALUE OF 'BS'
000D                 9 CR        EQU     0DH        ;              'CR'
0007                10 BELL      EQU     07H        ; BELL CHARACTER
                    11 ;
                    12 ;         KEYBOARD INPUT ROUTINE FOR SCAT PROCESSOR
                    13 ;
                    14 ;         REGISTERS UPON INPUT:
                    15 ;                 (BC)=ADDR OF CHARACTER COUNT TO BE ENTERED
                    16 ;                 (DE)=BUFFER ADDR INTO WHICH THE CHARACTERS GO
                    17 ;
0000 EB             18 KEYBRD:   XCHG               ;BUFFER POINTER TO HL
0001 0A             19           LDAX    B          ;GET CHARACTER COUNT
0002 57             20           MOV     D,A        ;CHARACTER COUNT TO D
0003 5F             21           MOV     E,A        ;LENGTH OF STRING TO E ALSO
0004 CD3C00    C    22 NEXT:     CALL    GETCH      ;C(C)=C(A)='CHAR'
0007 FE08           23           CPI     BACK       ;BACK SPACE?
0009 C22100    C    24           JNZ     SKIP1      ;IF NOT SKIP
000C 7A             25           MOV     A,D        ;START OF LINE?
000D BB             26           CMP     E          ;IF SO, THEN 'BLEEP' AND IGNORE
000E C21900    C    27           JNZ     BKSPC      ;IF NOT BACK SPACE POINTERS AND CURSOR
0011 0E07           28           MVI     C,BELL     ;GET BELL CHARACTER
0013 CD0000    E    29           CALL    ECHO
0016 C30400    C    30           JMP     NEXT
0019 14             31 BKSPC:    INR     D          ;BACK SPACE
001A 2B             32           DCX     H          ;POINTER
001B CD0000    E    33           CALL    ECHO       ;ALSO ECHO ASCII BACKSPACE TO CONSOLE
001E C30400    C    34           JMP     NEXT
0021 FE0D           35 SKIP1:    CPI     CR         ;CARRIAGE RETURN?
0023 C23200    C    36           JNZ     SKIP2      ;IF NOT SKIP
0026 CD0000    E    37           CALL    ECHO       ;IF SO, THEN ECHO CR & LF
0029 3E20           38           MVI     A,' '      ;ALSO, FILL OTHER BUFFER SPACE WITH BLANKS
002B 77             39 FILL:     MOV     M,A
002C 23             40           INX     H          ;STEP POINTER
002D 15             41           DCR     D
002E C22B00    C    42           JNZ     FILL
0031 C9             43           RET                ;RETURN WHEN FINISHED
0032 CD0000    E    44 SKIP2:    CALL    ECHO       ;ECHO CHARACTER
0035 71             45           MOV     M,C        ;PUT IT INTO BUFFER
0036 23             46           INX     H
0037 15             47           DCR     D          ;DECREMENT COUNTER
0038 C20400    C    48           JNZ     NEXT       ;LOOP UNTIL END O· BUFFER
003B C9             49           RET
                    50 ;
003C CD4300    C    51 GETCH:    CALL    CI         ;GET CHAR FROM TERMINAL
003F E67F           52           ANI     07FH       ;STRIP OF PARITY
0041 4F             53           MOV     C,A        ;PUT VALUE IN C REG
0042 C9             54           RET
                    55 ;
0043 DBCD           56 CI:       IN      0CDH       ;GET STATUS OF CONSOLE
0045 E602           57           ANI     02H        ;RCVR BUFFER READY?
0047 CA4300    C    58           JZ      CI         ; IF NOT , TRY AGAIN
004A DBCC           59           IN      0CCH       ; IF YES , GET CHARACTER
004C C9             60           RET
                    61 ;
                    62           END

PUBLIC SYMBOLS
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          KEYIN    PAGE    2

CI      C 0043    GETCH  C 003C    KEYBRD C 0000

EXTERNAL SYMBOLS
ECHO    E 0000

USER SYMBOLS
BACK    A 0008    BELL   A 0007    BKSPC  C 0019    CI     C 0043    CR     A 000D    ECHO   E 0000
   FILL    C 002B
GETCH   C 003C    KEYBRD C 0000    NEXT   C 0004    SKIP1  C 0021    SKIP2  C 0032

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:LDJMPS.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        LDJMPS   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1         NAME LDJMPS
                      2 ;
                      3 PUBLIC  LDJMPS
                      4 ;
                      5         ASEG
                      6 EXTRN   CZTINT
 4000                 7         ORG     4000H
 4000 C30000   E      8         JMP     CZTINT   ;LEVEL 0 INTERRUPT, CZT INTEGRATION TIMER
 4003 00              9         NOP
 4004 C9             10         RET              ;LEVEL 1 INTERRUPT, BI-PHASE-L, PARALLEL P
                        ORT A2
 4005 00             11         NOP
 4006 00             12         NOP
 4007 00             13         NOP
 4008 C9             14         RET              ;LEVEL 2 INTERRUPT, BUSS INT 2
 4009 00             15         NOP
 400A 00             16         NOP
 400B 00             17         NOP
 400C C9             18         RET              ;LEVEL 3 INTERRUPT,STROBE, PARALLEL PORT B
                        2
 400D 00             19         NOP
 400E 00             20         NOP
 400F 00             21         NOP
 4010 C9             22         RET              ;LEVEL 4 INTERRUPT,SYNC, BUSS INT 1
 4011 00             23         NOP
 4012 00             24         NOP
 4013 00             25         NOP
 4014 C9             26         RET              ;LEVEL 5 INTERRUPT, GND
 4015 00             27         NOP
 4016 00             28         NOP
 4017 00             29         NOP
 4018 C9             30         RET              ;LEVEL 6 INTERRUPT, GND
 4019 00             31         NOP
 401A 00             32         NOP
 401B 00             33         NOP
 401C C9             34         RET              ;LEVEL 7 INTERRUPT, GND
 401D 00             35         NOP
 401E 00             36         NOP
 401F 00             37         NOP
 4020 C9             38 LDJMPS: RET
                     39         END

PUBLIC SYMBOLS
LDJMPS A 4020

EXTERNAL SYMBOLS
CZTINT E 0000

USER SYMBOLS
CZTINT E 0000    LDJMPS A 4020

ASSEMBLY COMPLETE,    NO ERRORS
```

```
FORTRAN COMPILER
             PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT MFLAG
OBJECT MODULE PLACED IN :F1:MFLAG.OBJ
COMPILER INVOKED BY:  FORT80 :F1:MFLAG.SRC DEBUG


                    SUBROUTINE MFLAG(IC,IOF,IOUT,IB,NZ)
          C
          C    ***********  MOVES FLAG DATA WORDS TO OUTPUT LINE    *****
          C
                    INTEGER*1 IOF(5),IOUT(128)
                    INTEGER*2 IB,NZ,IC
          C
          C    ****  IB=BAND IDENT,   NZ=POLARIZ IDENT
          C    ****  IC=COL COUNTER
          C            IOF=FLAG WORD BUFFER, IOUT=OUTPUT BUFFER
          C
                    DO 10 I=1,5
                    IOUT(IC-1+I)=IOF(I)
               10   CONTINUE
                    IOUT(IC+5)=IB
                    IOUT(IC+6)=NZ
          C
                    DO 20 K=IC+7,128
                    IOUT(K)=#0DDH
               20   CONTINUE
          C
                    RETURN
                    END


MODULE INFORMATION:

     CODE AREA SIZE      = 00AEH     174D
     VARIABLE AREA SIZE = 000EH      14D
     MAXIMUM STACK SIZE = 0006H       6D
     23 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT MFLAG

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
FORTRAN COMPILER
             PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT MFPNUM
OBJECT MODULE PLACED IN :F1:MFPNUM.OBJ
COMPILER INVOKED BY:  FORT80 :F1:MFPNUM.SRC DEBUG


                SUBROUTINE MFPNUM(FPNBR,ICOL,IBPT,IOUT,IBCD,NK)
                DIMENSION FPNBR(8),IBPT(8)
                INTEGER*1 IBCD(4),IOUT(128,70)
          C*** NK SPECIFIES HOW MANY NBRS TO CONVERT & MOVE
          C
          C     UP TO 8 FLTG POINT NBRS CAN BE HANDLED
          C
                DO 30 K=1,NK
                FP=FPNBR(K)
                IF(FP.LT.-99.9)FP=-99.9
                IF(FP.GT.99.9) FP=99.9
                INUM=IFIX(FP*10.)
          C  :::  :::   :::   SET SIGN OF NBR    :::    :::
                IBCD(4)=10
                IF(INUM.GE.0)GO TO 5
                IBCD(4)=14
                INUM=-INUM
          C
          C   ::::   UNPACK INTO BCD DIGITS   ::::
          C
           5    DO 10 J=1,2
                IH=(INUM/10)*10
                IBCD(J)=INUM-IH
                INUM=IH/10
           10   CONTINUE
                IBCD(3)=INUM
          C
          C   :::   PACK INTO BI-PHASE-L OUTPUT   :::
          C
           15   DO 20 L=1,2
                INDX=ICOL-1+(K-1)*2+L
                J=1+(L-1)*2
                IBCD(J)=IBCD(J)*16+IBCD(J+1)
                IOUT(INDX,IBPT(K))=IBCD(J)
           20   CONTINUE
           30   CONTINUE
                RETURN
                END


MODULE INFORMATION:

     CODE AREA SIZE      = 01D2H    466D
     VARIABLE AREA SIZE  = 001EH     30D
     MAXIMUM STACK SIZE  = 0008H      8D
     38 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT MFPNUM

     0 TOTAL PROGRAM ERROR(S)
```

```
FORTRAN COMPILER
                PAGE   2

      END OF FORTRAN COMPILATION
```

```
ASM80 :F1:MINHR.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         MINHR    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                     1 ;         SUBROUTINE MINHR(IMH,NU,NT,I10)
                     2 ;
                     3 ;
                     4           NAME    MINHR
                     5 ;
                     6 ;         EVALUATES MINUTES OR HOURS BY:
                     7 ;
                     8 ;                 IMH=NT*I10+NU
                     9 ;                         WHERE I10=10
                    10 ;
                    11 ;
 006C               12 IAD       EQU     6CH
 006E               13 IMULT     EQU     6EH
                    14 ;
                    15 EXTRN     INTLOD,AMDCMD,AMDSTR,AMDLOD,INTSTR
                    16           PUBLIC  MINHR
                    17 ;
                    18           CSEG
                    19 ;
 0000 E1            20 MINHR:    POP     H        ;SAVE RETURN ADDRESS
 0001 CD0000    E   21           CALL    INTLOD   ;NT ↑
 0004 42            22           MOV     B,D
 0005 4B            23           MOV     C,E
 0006 CD0000    E   24           CALL    INTLOD   ;I10 ↑
 0009 3E6E          25           MVI     A,IMULT
 000B CD0000    E   26           CALL    AMDCMD   ;X
 000E C1            27           POP     B
 000F CD0000    E   28           CALL    INTLOD   ;NU ↑
 0012 3E6C          29           MVI     A,IAD
 0014 CD0000    E   30           CALL    AMDCMD   ;+
 0017 C1            31           POP     B
 0018 CD0000    E   32           CALL    INTSTR   ;SAVE IN IMH
 001B E9            33           PCHL             ;RETURN
                    34           ;
                    35           END

PUBLIC SYMBOLS
MINHR  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    IAD    A 006C    IMULT  A 006E
INTLOD E 0000    INTSTR E 0000    MINHR  C 0000

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:OUTPUT.SRC XREF DEBUG PAGELENGTH(53)

ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        OUTPUT   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                     1           NAME OUTPUT
                     2 ;
                     3           CSEG
                     4 ;
                     5           PUBLIC MSGOUT
                     6 ;
                     7           EXTRN   CO
                     8 ;
                     9 ;         FUNCTION:
                    10 ;                 OUTPUTS A CHARACTER STRING TO THE CRT OR CONSOLE
                    11 ;                 LOGGING DEVICE AT PORT LOCATION 0CCH.
                    12 ;
                    13 ;         REGISTERS:
                    14 ;                 C(BC)=ADDRESS OF CHARACTER COUNT TO SEND
                    15 ;                 C(DE)=ADDRESS OF BUFFER CONTAINING THE STRING
                    16 ;
                    17 ;         REGISTERS ALTERED:
                    18 ;                 C(HL), C(BC), C(A)
                    19 ;
  0000 EB           20 MSGOUT: XCHG              ;SET POINTER TO BYTE BUFFER
  0001 0A           21         LDAX    B         ;GET COUNT FROM ADDR IN (BC)
  0002 47           22         MOV     B,A       ;SET COUNTER OF BYTES
  0003 4E           23 GBYT:   MOV     C,M       ;GET A CHARACTER
  0004 CD0000   E   24         CALL    CO        ;SEND IT OUT
  0007 23           25         INX     H         ;STEP BUFFER POINTER
  0008 05           26         DCR     B         ;DROP ONE FROM COUNTER
  0009 C20300   C   27         JNZ     GBYT      ;IF NOT DONE , GET NEXT BYTE
                    28 ;       CLEAR KEY BUFFER
  000C DBCD         29         IN      0CDH      ;GET STATUS
  000E E602         30         ANI     02H       ;CHECK FOR PENDING CHARACTER
  0010 CA1500   C   31         JZ      XIT       ;IF NOT CONTINUE
  0013 DBCC         32         IN      0CCH      ;GET CHARACTER
  0015 C9           33 XIT:    RET               ;RETURN TO CALLING ROUTINE
                    34 ;
                    35         END

PUBLIC SYMBOLS
MSGOUT C 0000

EXTERNAL SYMBOLS
```

```
CO      E 0000

USER SYMBOLS
CO      E 0000    GBYT    C 0003    MSGOUT C 0000    XIT     C 0015

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:PCPN.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        PCPN     PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1 ;          SUBROUTINE PCPN(PN,TI,PC,TC,ALT,VEL)
                      2 ;
                      3            NAME     PCPN
                      4 ;
                      5 ;
  00F0                6 PORT       EQU      00F0H
  0012                7 MULT       EQU      12H
  0013                8 DIV        EQU      13H
  0017                9 ENTR       EQU      17H
  0019               10 EXCHG      EQU      19H
                     11 ;
                     12            EXTRN    AMDLOD
                     13            EXTRN    AMDSTR
                     14            EXTRN    AMDCMD
                     15            EXTRN    GIVE
                     16 ;
                     17            PUBLIC   PCPN
                     18 ;
                     19            CSEG
                     20 ;
  0000 E1            21 PCPN:      POP      H                ;SAVE RETURN ADDRESS
  0001 CD0000    E   22            CALL     AMDLOD           ;ALT ↑
  0004 42            23            MOV      B,D
  0005 4B            24            MOV      C,E
  0006 CD0000    E   25            CALL     AMDLOD           ;VEL ↑
  0009 3E13          26            MVI      A,DIV
  000B CD0000    E   27            CALL     AMDCMD           ;/
  000E 3E17          28            MVI      A,ENTR
  0010 CD0000    E   29            CALL     AMDCMD           ;↑
  0013 C1            30            POP      B
  0014 CD0000    E   31            CALL     AMDLOD           ;TC ↑
  0017 3E13          32            MVI      A,DIV
  0019 CD0000    E   33            CALL     AMDCMD           ;/
  001C C1            34            POP      B
  001D CD0000    E   35            CALL     AMDSTR           ;SAVE IT IN PC
  0020 C1            36            POP      B
  0021 CD0000    E   37            CALL     AMDLOD           ;TI ↑
  0024 3E19          38            MVI      A,EXCHG
  0026 CD0000    E   39            CALL     AMDCMD           ;EXCHANGE X,Y
  0029 3E13          40            MVI      A,DIV
  002B CD0000    E   41            CALL     AMDCMD           ;/
  002E 113E00    C   42            LXI      D,HALF
  0031 CD0000    E   43            CALL     GIVE             ;.5 ↑
  0034 3E12          44            MVI      A,MULT
  0036 CD0000    E   45            CALL     AMDCMD           ;X
  0039 C1            46            POP      B
  003A CD0000    E   47            CALL     AMDSTR           ;SAVE IT IN PN
  003D E9            48            PCHL                      ;RETURN
                     49 ;
  003E 00            50 HALF:      DB       00H,00H,80H,00H
  003F 00
  0040 80
  0041 00
                     51            END

PUBLIC SYMBOLS
PCPN   C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GIVE   E 0000

USER SYMBOLS
```

```
AMDCMD E 0000     AMDLOD E 0000     AMDSTR E 0000     DIV    A 0013     ENTR   A 0017
EXCHG  A 0019     GIVE   E 0000     HALF   C 003E     MULT   A 0012     PCPN   C 0000
PORT   A 00F0

ASSEMBLY COMPLETE,    NO ERRORS
```

```
FORTRAN COMPILER
              PAGE    1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT PRTVLU
OBJECT MODULE PLACED IN :F1:PRTVLU.OBJ
COMPILER INVOKED BY:  FORT80 :F1:PRTVLU.SRC DEBUG


                     SUBROUTINE PRTVLU(CR,IR,N,IERR,X)
           C
           C    !!! PRINTS MESSAGE OF N CHARACTERS ALREADY IN
           C        BUFFER IR.  NEXT, PRINTS VALUE OF A FLOATING
           C        POINT NUMBER IN F10.3 FORMAT LOCATED IN X.
           C
           C        NOTE: *** N.LE.30 ***
           C
                     INTEGER*1 IR(30),N
                     CHARACTER*30 CR
           C
                     CALL CRLF
                     CALL MSGOUT(N,IR)
                     WRITE(CR,10,ERR=20)X
                10   FORMAT(F10.3,20X)
                     CALL MSGOUT(N,IR)
                15   RETURN
           C
                20   IERR=1
                     GO TO 15
           C
                     END

MODULE INFORMATION:

      CODE AREA SIZE     = 0091H    145D
      VARIABLE AREA SIZE = 001EH     30D
      MAXIMUM STACK SIZE = 0008H      8D
      22 LINES READ

      0 PROGRAM ERROR(S) IN PROGRAM UNIT PRTVLU

      0 TOTAL PROGRAM ERROR(S)
      END OF FORTRAN COMPILATION
```

```
ASM80 :F1:RESTRT.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          DWAIT    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1           NAME DWAIT
                      2 ;
                      3           CSEG
                      4           EXTRN   CO,CRLF,DELAY
                      5 ;
                      6           PUBLIC DWAIT
                      7 ;
                      8 ;    FUNCTION:
                      9 ;         LINKAGE ROUTINE FOR FORTRAN ERROR RECOVERY.
                     10 ;         CONTROL REMAINS HERE UNTIL THE MACHINE IS RESET.
                     11 ;
                     12 ;
  0000 CD0000    E   13 DWAIT:    CALL    CRLF
  0003 060F          14           MVI     B,0FH     ;SET COUNT
  0005 0E2A          15 LOOP:     MVI     C,'*'     ;GET '*'
  0007 CD0000    E   16           CALL    CO        ;OUTPUT '*'
  000A 0E07          17           MVI     C,07H     ;INSERT BELL CHAR
  000C CD0000    E   18           CALL    CO        ;SEND IT TO CRT
  000F CD0000    E   19           CALL    DELAY     ;WAIT AWHILE , ALTERS C(A), C(C)
  0012 05            20           DCR     B         ;COUNT
  0013 C20500    C   21           JNZ     LOOP      ;     DOWN
  0016 CD0000    E   22 LP2:      CALL    DELAY     ;DELAY AND
  0019 C31600    C   23           JMP     LP2       ;         WAIT HERE FOR RESET OR INTERRUPT
                     24           ;
                     25           END

 PUBLIC SYMBOLS
 DWAIT  C 0000

 EXTERNAL SYMBOLS
 CO      E 0000    CRLF    E 0000    DELAY   E 0000

 USER SYMBOLS
 CO      E 0000    CRLF    E 0000    DELAY   E 0000    DWAIT   C 0000    LOOP    C 0005    LP2     C 00

 ASSEMBLY COMPLETE,    NO ERRORS
```

```
FORTRAN COMPILER
                PAGE   1

ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT RUNLMT
OBJECT MODULE PLACED IN :F1:RUNLMT.OBJ
COMPILER INVOKED BY:  FORT80 :F1:RUNLMT.SRC DEBUG


                  SUBROUTINE RUNLMT(PREV,IOVER)
                  DIMENSION PREV(5),PARM(5)
                  INTEGER*1 IOVER(5)
                  LOGICAL LZ,UZ
                  COMMON T1,PARM,BMW
            C
            C *** ROUTINE PERFORMS RUNNING LIMIT CHECK ON A/C DATA ***
            C
                  IF(IOVER(1).NE.0)GO TO 10
                  AL=PREV(1)-15.24
                  AU=PREV(1)+15.24
                  LZ=(PARM(1).LT.AL)
                  UZ=(PARM(1).GT.AU)
                  IF(LZ.OR.UZ)PARM(1)=PREV(1)
               10 CONTINUE
                  DO 20 L=2,4
                  IF(IOVER(L).NE.0) GO TO 20
                  AL=PREV(L)-0.0873
                  AU=PREV(L)+0.0873
                  LZ=(PARM(L).LT.AL)
                  UZ=(PARM(L).GT.AU)
                  IF(LZ.OR.UZ)PARM(L)=PREV(L)
               20 CONTINUE
                  IF(IOVER(5).NE.0)GO TO 30
                  AL=PREV(5)-2.57
                  AU=PREV(5)+2.57
                  LZ=(PARM(5).LT.AL)
                  UZ=(PARM(5).GT.AU)
                  IF(LZ.OR.UZ)PARM(5)=PREV(5)
             30   RETURN
                  END

MODULE INFORMATION:

     CODE AREA SIZE     = 01AEH    430D
     VARIABLE AREA SIZE = 0010H     16D
     MAXIMUM STACK SIZE = 0004H      4D
     31 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT RUNLMT

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
ASM80 :F1:TIMEFP.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         TIMEFP   PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                            ;      SUBROUTINE TIMEFP(T1,F10,ITS,F60,IM,IH,I60)
                            ;
                            ;
                                   NAME    TIMEFP
                            ;
                            ;      COMPUTES FLOATING POINT VALUE OF TIME IN SECONDS BY:
                            ;
                            ;              T1=FLOAT(IH*I60+IM)*F60+FLOAT(ITS)/F10
                            ;
                            ;                      WHERE I60=60, F60=60.,AND F10=10.
                            ;
                            ;
  0012                      MULT   EQU     12H
  0013                      DIV    EQU     13H
  0010                      AD     EQU     10H
  006C                      IAD    EQU     6CH
  006E                      IMULT  EQU     6EH
  001D                      FLOAT  EQU     1DH
                            ;
                            EXTRN  INTLOD,AMDCMD,AMDSTR,AMDLOD
                            ;
                            PUBLIC TIMEFP
                            ;
                            CSEG
                            ;
  0000 E1                   TIMEFP: POP    H       ;SAVE RETURN ADDR
  0001 CD0000     E                CALL    INTLOD  ;IH ↑
  0004 42                          MOV     B,D
  0005 4B                          MOV     C,E
  0006 CD0000     E                CALL    INTLOD  ;I60 ↑
  0009 3E6E                        MVI     A,IMULT
  000B CD0000     E                CALL    AMDCMD  ;X
  000E C1                          POP     B
  000F CD0000     E                CALL    INTLOD  ;IM ↑
  0012 3E6C                        MVI     A,IAD
  0014 CD0000     E                CALL    AMDCMD  ;+
  0017 3E1D                        MVI     A,FLOAT
  0019 CD0000     E                CALL    AMDCMD  ;FLOAT
  001C C1                          POP     B
  001D CD0000     E                CALL    AMDLOD  ;F60 ↑
  0020 3E12                        MVI     A,MULT
  0022 CD0000     E                CALL    AMDCMD  ;X
  0025 C1                          POP     B
  0026 CD0000     E                CALL    INTLOD  ;ITS ↑
  0029 3E1D                        MVI     A,FLOAT
  002B CD0000     E                CALL    AMDCMD  ;FLOAT
  002E C1                          POP     B
  002F CD0000     E                CALL    AMDLOD  ;F10 ↑
  0032 3E13                        MVI     A,DIV
  0034 CD0000     E                CALL    AMDCMD  ;/
  0037 3E10                        MVI     A,AD
  0039 CD0000     E                CALL    AMDCMD  ;+
  003C C1                          POP     B
  003D CD0000     E                CALL    AMDSTR  ;SAVE AT T1
  0040 E9                          PCHL            ;RETURN
                                   ;
                                   END

  PUBLIC SYMBOLS
  TIMEFP C 0000

  EXTERNAL SYMBOLS
```

```
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0C00

USER SYMBOLS
AD     A 0010    AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    DIV    A 0013
FLOAT  A 001D    IAD    A 006C    IMULT  A 006E    INTLOD E 0000    MULT   A 0012
TIMEFP C 0000

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:TMP12.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         TMP12    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT
                      1         NAME    TMP12
                      2 ;
                      3 ;       SUBROUTINE TMP12(TMP1,VEL,X12)
                      4 ;
                      5 ;       :::  TMP1=X12*(VEL**2), WHERE X12=XK1 OR XK2
                      6 ;
  0017                7 PUSHT   EQU     17H
  0012                8 MULT    EQU     12H
                      9 ;
                     10 EXTRN   AMDLOD,AMDCMD,AMDSTR
                     11 ;
                     12 PUBLIC  TMP12
                     13 ;
                     14 CSEG
                     15 ;
  0000 E1            16 TMP12:  POP     H         ;SAVE RTN ADDR OFF STACK
  0001 CD0000    E   17         CALL    AMDLOD    ;VEL ↑
  0004 3E17          18         MVI     A,PUSHT
  0006 CD0000    E   19         CALL    AMDCMD    ;VEL ↑
  0009 3E12          20         MVI     A,MULT
  000B CD0000    E   21         CALL    AMDCMD    ;VEL*VEL
  000E 42            22         MOV     B,D
  000F 4B            23         MOV     C,E
  0010 CD0000    E   24         CALL    AMDLOD    ;XK1 OR XK2 ↑
  0013 3E12          25         MVI     A,MULT
  0015 CD0000    E   26         CALL    AMDCMD    ;X12*(VEL**2)
  0018 C1            27         POP     B
  0019 CD0000    E   28         CALL    AMDSTR    ;TMP1 = "
  001C E9            29         PCHL              ;RETURN
                     30         ;
                     31         END

PUBLIC SYMBOLS
TMP12  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    MULT    A 0012    PUSHT   A 0017    TMP12   C 00

ASSEMBLY COMPLETE,    NO ERRORS
```

ORIGINAL PAGE IS
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```
ASM80 :F1:TRM1.SRC DEBUG PAGELENGTH(75)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          TRM1      PAGE    1

  LOC  OBJ          LINE         SOURCE STATEMENT

                       1           NAME TRM1
                       2 ;
                       3 ;         SUBROUTINE TRM1(T1,BMW,ANG,ALT,RL)
                       4 ;
                       5 ;         ::: T1=2.*TAN(BMW/2.)*(ALT**2)/COS(RL)/COS(ANG)
                       6 ;
 0017                  7 PUSHT     EQU     17H
 0003                  8 COS       EQU     03H
 0012                  9 MULT      EQU     12H
 0010                 10 FADD      EQU     10H
 0013                 11 FDIV      EQU     13H
 0004                 12 TAN       EQU     04H
                      13 ;
                      14 EXTRN     AMDLOD,AMDCMD,AMDSTR,GIVE
                      15 ;
                      16 PUBLIC    TRM1
                      17 ;
                      18 CSEG
                      19 ;
 0000 E1              20 TRM1:     POP     H          ;HOLD RTN ADDR
 0001 CD0000     E    21           CALL    AMDLOD     ;ALT ↑
 0004 3E17            22           MVI     A,PUSHT
 0006 CD0000     E    23           CALL    AMDCMD     ;ALT ↑
 0009 3E12            24           MVI     A,MULT
 000B CD0000     E    25           CALL    AMDCMD     ;ALT*ALT
 000E 42              26           MOV     B,D
 000F 4B              27           MOV     C,E
 0010 CD0000     E    28           CALL    AMDLOD     ;RL ↑
 0013 3E03            29           MVI     A,COS
 0015 CD0000     E    30           CALL    AMDCMD     ;COS(RL):ALT**2:-:-
 0018 3E13            31           MVI     A,FDIV
 001A CD0000     E    32           CALL    AMDCMD     ;(ALT**2)/COS(RL):-:-:-
 001D C1              33           POP     B
 001E CD0000     E    34           CALL    AMDLOD     ;ANG ↑
 0021 3E03            35           MVI     A,COS
 0023 CD0000     E    36           CALL    AMDCMD     ;COS(ANG):(ALT...):-:-
 0026 3E13            37           MVI     A,FDIV
 0028 CD0000     E    38           CALL    AMDCMD     ;((ALT...)/COS(ANG):-:-:-
 002B C1              39           POP     B
 002C CD0000     E    40           CALL    AMDLOD     ;BMW ↑
 002F 115300     C    41           LXI     D,TWO
 0032 CD0000     E    42           CALL    GIVE       ;2. ↑
 0035 3E13            43           MVI     A,FDIV
 0037 CD0000     E    44           CALL    AMDCMD     ;BMW/2.:(ALT...ANG)
 003A 3E04            45           MVI     A,TAN
 003C CD0000     E    46           CALL    AMDCMD     ;TAN(BMW/2.):(ALT....):-:-
 003F 3E12            47           MVI     A,MULT
 0041 CD0000     E    48           CALL    AMDCMD     ;TAN(..)*(ALT...)
 0044 3E17            49           MVI     A,PUSHT
 0046 CD0000     E    50           CALL    AMDCMD     ;TAN(..)*(ALT...):TAN(..)*(ALT...)
 0049 3E10            51           MVI     A,FADD
 004B CD0000     E    52           CALL    AMDCMD     ;2.*TAN(..)*(ALT..)
 004E C1              53           POP     B
 004F CD0000     E    54           CALL    AMDSTR     ;T1=
 0052 E9              55           PCHL               ;RETURN
                      56           ;
 0053 00              57 TWO:      DB      00H,00H,80H,02H
 0054 00
 0055 80
 0056 02
                      58           ;
                      59           END
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          TRM1      PAGE    2


PUBLIC SYMBOLS
TRM1   C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GIVE   E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    COS    A 0003    FADD   A 0010    FDIV   A 00
   GIVE   E 0000
MULT   A 0012    PUSHT  A 0017    TAN    A 0004    TRM1   C 0000    TWO    C 0053

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:TRM23.SRC DEBUG PAGELENGTH(75)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        TRM23    PAGE     1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1           NAME    TRM23
                      2 ;
                      3 ;         SUBROUTINE TRM23(TRM,TMP1,RL,DR)
                      4 ;
                      5 ;         :: TRM=(-TAN(DR)*TAN(RL)+SQRT(TAN(RL)**2*(TMP1-1.)+TMP1*COS(DR)**2-
1.))/;
                                  (1.-TMP1*COS(DR)**2),
                      6 ;                 WHERE TRM = TRM2 OR TRM3 OF AREA EQUATION
                      7 ;
  0017                8 PUSHT     EQU     17H
  0012                9 MULT      EQU     12H
  0011               10 FSUB      EQU     11H
  0010               11 FADD      EQU     10H
  0001               12 SQRT      EQU     01H
  0004               13 TAN       EQU     04H
  0003               14 COS       EQU     03H
  0019               15 XCHF      EQU     19H
  0013               16 FDIV      EQU     13H
                     17 ;
                     18 EXTRN     AMDLOD,AMDCMD,AMDSTR,GET,GIVE
                     19 ;
                     20 PUBLIC    TRM23
                     21 ;
                     22 CSEG
                     23 ;
  0000 E1            24 TRM23:    POP     H        ;SAVE RTN ADDR
  0001 220000   D    25           SHLD    ISAVE    ;IN INTERNAL BUFFER
  0004 EB            26           XCHG             ;HOLD CY OF DR ADDR IN RP(HL)
  0005 CD0000   E    27           CALL    AMDLOD   ;RL ↑
  0008 3E04          28           MVI     A,TAN
  000A CD0000   E    29           CALL    AMDCMD   ;TAN(RL)
  000D 3E17          30           MVI     A,PUSHT
  000F CD0000   E    31           CALL    AMDCMD   ;TAN(RL):TAN(RL):-:-
  0012 CD0000   E    32           CALL    AMDCMD   ;   "    :   "    :TAN(RL):-
  0015 110200   D    33           LXI     D,ISAVE+2
  0018 CD0000   E    34           CALL    GET      ;SAVE CY OF TAN(RL)
  001B 3E12          35           MVI     A,MULT
  001D CD0000   E    36           CALL    AMDCMD   ;TAN(RL)**2
  0020 C1            37           POP     B
  0021 CD0000   E    38           CALL    AMDLOD   ;TMP1 ↑
  0024 3E17          39           MVI     A,PUSHT
  0026 CD0000   E    40           CALL    AMDCMD   ;TMP1:TMP1:TAN(RL)**2:-
  0029 110600   D    41           LXI     D,ISAVE+6
  002C CD0000   E    42           CALL    GET      ;SAVE CY OF TMP1
  002F 11C600   C    43           LXI     D,ONE
  0032 CD0000   E    44           CALL    GIVE     ;1. ↑
  0035 3E11          45           MVI     A,FSUB
  0037 CD0000   E    46           CALL    AMDCMD   ;(TMP1-1.):TAN(RL)**2:-:-
  003A 3E12          47           MVI     A,MULT
  003C CD0000   E    48           CALL    AMDCMD   ;(TMP1-1.)*TAN(RL)**2:-:-:-
  003F 11C600   C    49           LXI     D,ONE
  0042 CD0000   E    50           CALL    GIVE     ;1. ↑
  0045 3E11          51           MVI     A,FSUB
  0047 CD0000   E    52           CALL    AMDCMD   ;(TMP1.....**2)-1.:-:-:-
  004A 44            53           MOV     B,H
  004B 4D            54           MOV     C,L
  004C CD0000   E    55           CALL    AMDLOD   ;DR ↑
  004F 3E03          56           MVI     A,COS
  0051 CD0000   E    57           CALL    AMDCMD   ;COS(DR)
  0054 3E17          58           MVI     A,PUSHT
  0056 CD0000   E    59           CALL    AMDCMD   ;COSD:COSD:(TMP1...):-:-
  0059 3E12          60           MVI     A,MULT
  005B CD0000   E    61           CALL    AMDCMD   ;(COS(DR)**2):(TMP1...):-:-
  005E 3E17          62           MVI     A,PUSHT
```

```
 LOC  OBJ          LINE        SOURCE STATEMENT

 0060 CD0000   E    63          CALL    AMDCMD   ;COSD**2:COSD**2:(TMP1...):-
 0063 110A00   D    64          LXI     D,ISAVE+10
 0066 CD0000   E    65          CALL    GET      ;SAVE CY OF COS(DR)**2
 0069 110600   D    66          LXI     D,ISAVE+6
 006C CD0000   E    67          CALL    GIVE     ;TMP1 ↑
 006F 3E12          68          MVI     A,MULT
 0071 CD0000   E    69          CALL    AMDCMD   ;TMP1*COSD**2:(...)
 0074 3E10          70          MVI     A,FADD
 0076 CD0000   E    71          CALL    AMDCMD   ;((TAN**2 ...-1.):-:-:-
 0079 3E01          72          MVI     A,SQRT
 007B CD0000   E    73          CALL    AMDCMD   ;SQRT(...)
 007E 42            74          MOV     B,D
 007F 4B            75          MOV     C,E
 0080 CD0000   E    76          CALL    AMDLOD   ;DR ↑
 0083 3E04          77          MVI     A,TAN
 0085 CD0000   E    78          CALL    AMDCMD   ;TAN(DR)
 0088 110200   D    79          LXI     D,ISAVE+2
 008B CD0000   E    80          CALL    GIVE     ;TAN(RL) ↑
 008E 3E12          81          MVI     A,MULT
 0090 CD0000   E    82          CALL    AMDCMD   ;TANR*TAND:SQRT(...)
 0093 3E11          83          MVI     A,FSUB
 0095 CD0000   E    84          CALL    AMDCMD   ;SQRT(..)-TANR*TAND
 0098 110600   D    85          LXI     D,ISAVE+6
 009B CD0000   E    86          CALL    GIVE     ;TMP1 ↑
 009E 110A00   D    87          LXI     D,ISAVE+10
 00A1 CD0000   E    88          CALL    GIVE     ;COS(DR)**2 ↑
 00A4 3E12          89          MVI     A,MULT
 00A6 CD0000   E    90          CALL    AMDCMD   ;(TMP1*COSD**2):SQRT(..):-:-
 00A9 11C600   C    91          LXI     D,ONE
 00AC CD0000   E    92          CALL    GIVE     ;1. ↑
 00AF 3E19          93          MVI     A,XCHF
 00B1 CD0000   E    94          CALL    AMDCMD   ;(TMP1...):1.:SQRT(...):-
 00B4 3E11          95          MVI     A,FSUB
 00B6 CD0000   E    96          CALL    AMDCMD   ;1.-(TMP1..):SQRT(..)
 00B9 3E13          97          MVI     A,FDIV
 00BB CD0000   E    98          CALL    AMDCMD   ;(SQRT(..)-TAN(..))/(1. ..)
 00BE C1            99          POP     B
 00BF CD0000   E   100          CALL    AMDSTR   ;TRM1 =    "
 00C2 2A0000   D   101          LHLD    ISAVE
 00C5 E9           102          PCHL             ;RETURN
                   103          ;
 00C6 00           104 ONE:     DB      00H,00H,80H,01H
 00C7 00
 00C8 80
 00C9 01
                   105          ;
                   106 DSEG
                   107          ;
 0000              108 ISAVE:   DS      14
                   109          ;
                   110          END

PUBLIC SYMBOLS
TRM23  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GET    E 0000    GIVE   E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    COS    A 0003    FADD   A 0010    FDIV   A 001
   FSUB   A 0011
GET    E 0000    GIVE   E 0000    ISAVE  D 0000    MULT   A 0012    ONE    C 00C6    PUSHT  A 001
   SQRT   A 0001
TAN    A 0004    TRM23  C 0000    XCHF   A 0019
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        TRM23    PAGE    3

  LOC  OBJ         LINE        SOURCE STATEMENT
ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:TSECS.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0        TSECS    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1 ;        SUBROUTINE TSECS(ITS,ITN,IHD,IUN)
                       2 ;
                       3          NAME     TSECS
                       4 ;
                       5 ;        EVALUATES SECONDS BY:
                       6 ;
                       7 ;                 ITS=10*(ITN+10*IHD)+IUN
                       8 ;
                       9 ;
  006C                10 IAD      EQU      6CH
  006E                11 IMULT    EQU      6EH
                      12 ;
                      13          EXTRN    INTLOD,AMDCMD,AMDSTR,AMDLOD,INTSTR
                      14          PUBLIC   TSECS
                      15 ;
                      16          CSEG
                      17 ;
  0000 E1             18 TSECS:   POP      H         ;SAVE RETURN ADDR
  0001 CD0000    E    19          CALL     INTLOD    ;IHD ↑
  0004 013200    C    20          LXI      B,TEN
  0007 CD0000    E    21          CALL     INTLOD    ;10 ↑
  000A 3E6E           22          MVI      A,IMULT
  000C CD0000    E    23          CALL     AMDCMD    ;X
  000F C1             24          POP      B
  0010 CD0000    E    25          CALL     INTLOD    ;ITN
  0013 3E6C           26          MVI      A,IAD
  0015 CD0000    E    27          CALL     AMDCMD    ;+
  0018 013200    C    28          LXI      B,TEN
  001B CD0000    E    29          CALL     INTLOD    ;10 ↑
  001E 3E6E           30          MVI      A,IMULT
  0020 CD0000    E    31          CALL     AMDCMD    ;X
  0023 42             32          MOV      B,D
  0024 4B             33          MOV      C,E
  0025 CD0000    E    34          CALL     INTLOD    ;IUN ↑
  0028 3E6C           35          MVI      A,IAD
  002A CD0000    E    36          CALL     AMDCMD    ;+
  002D C1             37          POP      B
  002E CD0000    E    38          CALL     INTSTR    ;SAVE RESULT IN ITS
  0031 E9             39          PCHL               ;RETURN
                      40 ;
  0032 0A00           41 TEN:     DW       10
                      42          END

 PUBLIC SYMBOLS
 TSECS  C 0000

 EXTERNAL SYMBOLS
 AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000    INTSTR E 0000

 USER SYMBOLS
 AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    IAD    A 006C    IMULT  A 006E
 INTLOD E 0000    INTSTR E 0000    TEN    C 0032    TSECS  C 0000

 ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:UNPACK.SRC DEBUG PAGELENGTH(77) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          UNPACK   PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1          NAME UNPACK
                      2 ;
                      3 ;        FUNCTION: UNPACKS 58 NIBS OF NERDAS DATA INTO 55 BYTES.
                      4 ;                  C(BC)=ADDR OF NIBS,INPUT BUFFER; AND
                      5 ;                  C(DE)=ADDR OF BYTES,OUTPUT BUFFER.
                      6 ;
                      7 PUBLIC   UNPACK,RR4B
                      8 ;
                      9 CSEG
                     10 ;
  0000 03            11 UNPACK:  INX      B         ;SKIP FIRST 2 NIBS, FRAME SYNC PART 1
  0001 261B          12          MVI      H,01BH    ;SET BYTE COUNTER = 27D
  0003 0A            13          LDAX     B         ;GET SYNC NIB 3 AND FRAME NBR
  0004 12            14          STAX     D         ;STORE AT BYTE 1 LOCATION
                     15          ;
  0005 03            16 STEP:    INX      B         ;SET POINTERS TO NEXT
  0006 13            17          INX      D         ;BYTE, STARTING AT NIB 5
  0007 0A            18          LDAX     B         ;GET BYTE IN ACCUM
  0008 6F            19          MOV      L,A       ;SAVE A CY IN R(E)
  0009 E6F0          20          ANI      0F0H      ;STRIP OUT UPPER NIB
  000B CD1900    C   21          CALL     RR4B      ;ROTATE ACCUM 4 BITS RIGHT
  000E 12            22          STAX     D         ;SAVE UPPER NIB
  000F 13            23          INX      D         ;ADVANCE ADDR POINTER
  0010 7D            24          MOV      A,L       ;GET NEW CY OF BYTE
  0011 E60F          25          ANI      0FH       ;STRIP OUT LOWER NIB
  0013 12            26          STAX     D         ;SAVE AT NEXT BYTE LOC
  0014 25            27          DCR      H         ;SUB 1 FROM BYTE COUNT
  0015 C20500    C   28          JNZ      STEP      ;LOOP TILL DONE
  0018 C9            29          RET
                     30          ;
  0019 0F            31 RR4B:    RRC                ;ROTATE
  001A 0F            32          RRC                ;ACCUM
  001B 0F            33          RRC                ;RIGHT
  001C 0F            34          RRC                ;4 POSITIONS
  001D C9            35          RET                ;THEN RETURN
                     36          END

PUBLIC SYMBOLS
RR4B   C 0019    UNPACK C 0000

EXTERNAL SYMBOLS


USER SYMBOLS
RR4B   C 0019    STEP   C 0005    UNPACK C 0000

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ISIS-II FORTRAN-80 V2.0 COMPILATION OF PROGRAM UNIT VALID
OBJECT MODULE PLACED IN :F1:VALID.OBJ
COMPILER INVOKED BY:  FORT80 :F1:VALID.SRC DEBUG


                  SUBROUTINE VALID(DL,DF,IOV,IVAL,PARM)
        C
        C   *******     VALIDATES NERDAS DATA VALUES UNLESS THE OVER-RIDE FLAG IS
        C         SET.   IF VALUE IS OUTSIDE PRESET LIMITS, THE DEFAULT VALUE IS USED.
        C         WHENEVER DEFAULT VALUES ARE USED AN APPROPRIATE FLAG IS SET.
        C
                  INTEGER*1 IOV(5),IVAL
                  DIMENSION DL(5,2),DF(5),PARM(5)
                  LOGICAL LZ,UZ
        C
        C   ***   PARM IS AN ORDERED SET:  ALT,DRF,ROL,PCH,VEL
        C
                  IVAL=0
                  KK=16
        C
                  DO 20 K=1,5
                  IDFG=0
                  IF(IOV(K).NE.0) GO TO 10
                  LZ=(PARM(K).GE.DL(K,1))
                  UZ=(PARM(K).LE.DL(K,2))
                  IF(LZ.AND.UZ)GO TO 10
                  PARM(K)=DF(K)
                  IDFG=1
             10   CONTINUE
                  IF(IDFG.NE.0)IVAL=IVAL+KK
                  KK=KK/2
             20   CONTINUE
                  RETURN
                  END

MODULE INFORMATION:

     CODE AREA SIZE      = 010AH    266D
     VARIABLE AREA SIZE  = 0012H     18D
     MAXIMUM STACK SIZE  = 0006H      6D
     29 LINES READ

     0 PROGRAM ERROR(S) IN PROGRAM UNIT VALID

     0 TOTAL PROGRAM ERROR(S)
     END OF FORTRAN COMPILATION
```

```
ASM80 :F1:VELFP.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          VELFP     PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1 ;        SUBROUTINE VELFP(VEL,CVEL,ITN,IHD,IUN)
                       2 ;
                       3          NAME    VELFP
                       4 ;
                       5 ;
                       6 ;        COMPUTES VELOCITY IN METERS/SECOND:
                       7 ;
                       8 ;        VEL=FLOAT(IUN+10*(ITN+10*IHD))*CVEL
                       9 ;                WHERE CVEL=0.514
                      10 ;
                      11 ;
  0013                12          DIV     EQU     13H
  0012                13          MULT    EQU     12H
  006C                14          IAD     EQU     6CH
  006E                15          IMULT   EQU     6EH
  001D                16          FLOAT   EQU     1DH
                      17 ;
                      18          EXTRN   INTLOD,AMDCMD,AMDSTR,AMDLOD
                      19          PUBLIC  VELFP
                      20 ;
                      21          CSEG
                      22 ;
  0000 E1             23 VELFP:   POP     H       ;SAVE RETURN ADDR
  0001 CD0000    E    24          CALL    INTLOD  ;IHD ↑
  0004 014000    C    25          LXI     B,TEN
  0007 CD0000    E    26          CALL    INTLOD  ;10 ↑
  000A 3E6E           27          MVI     A,IMULT
  000C CD0000    E    28          CALL    AMDCMD  ;X
  000F C1             29          POP     B
  0010 CD0000    E    30          CALL    INTLOD  ;ITN
  0013 3E6C           31          MVI     A,IAD
  0015 CD0000    E    32          CALL    AMDCMD  ;+
  0018 014000    C    33          LXI     B,TEN
  001B CD0000    E    34          CALL    INTLOD  ;10 ↑
  001E 3E6E           35          MVI     A,IMULT
  0020 CD0000    E    36          CALL    AMDCMD  ;X
  0023 42             37          MOV     B,D
  0024 4B             38          MOV     C,E
  0025 CD0000    E    39          CALL    INTLOD  ;IUN ↑
  0028 3E6C           40          MVI     A,IAD
  002A CD0000    E    41          CALL    AMDCMD  ;+
  002D 3E1D           42          MVI     A,FLOAT
  002F CD0000    E    43          CALL    AMDCMD  ;FLOAT
  0032 C1             44          POP     B
  0033 CD0000    E    45          CALL    AMDLOD  ;CVEL ↑
  0036 3E12           46          MVI     A,MULT
  0038 CD0000    E    47          CALL    AMDCMD  ;X
  003B C1             48          POP     B
  003C CD0000    E    49          CALL    AMDSTR  ;SAVE RESULT IN VEL
  003F E9             50          PCHL            ;RETURN
  0040 0A00           51 TEN:     DW      10
                      52          END

PUBLIC SYMBOLS
VELFP  C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    INTLOD E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    DIV    A 0013    FLOAT  A 001D
IAD    A 006C    IMULT  A 006E    INTLOD E 0000    MULT   A 0012    TEN    C 0040
```

```
VELFP  C 0000

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:XK12.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          XK12      PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1          NAME    XK12
                       2 ;
                       3 ;        SUBROUTINE XK12(XK2,XK1,SLMDA,BNDW,FDOP)
                       4 ;
                       5 ;        :::     XK1 = 4./(SLMDA*(FDOP-BNDW/2.)**2
                       6 ;                XK2 = 4./(SLMDA*(FDOP+BNDW/2.)**2
                       7 ;
  0017                 8 PUSHT    EQU     17H
  0012                 9 FMUL     EQU     12H
  0019                10 EXCHG    EQU     19H
  0013                11 FDIV     EQU     13H
  0010                12 FADD     EQU     10H
  0011                13 FSUB     EQU     11H
  0018                14 ROL      EQU     18H
                      15 ;
                      16          EXTRN   AMDLOD,AMDSTR,AMDCMD,INTLOD,INTSTR,GIVE,GET
                      17 ;
                      18          PUBLIC  XK12
                      19 ;
                      20          CSEG
                      21 ;
  0000 E1             22 XK12:    POP     H          ;PULL RETURN ADDR OFF STACK
  0001 CD0000   E     23          CALL    AMDLOD     ;BNDW ↑
  0004 3E17           24          MVI     A,PUSHT
  0006 CD0000   E     25          CALL    AMDCMD     ;BNDW:BNDW:--:--
  0009 D5             26          PUSH    D
  000A 117B00   C     27          LXI     D,TWO
  000D CD0000   E     28          CALL    GIVE
  0010 3E13           29          MVI     A,FDIV
  0012 CD0000   E     30          CALL    AMDCMD     ;BNDW/2:BNDW:--:--
  0015 C1             31          POP     B
  0016 CD0000   E     32          CALL    AMDLOD     ;FDOP ↑
  0019 3E10           33          MVI     A,FADD
  001B CD0000   E     34          CALL    AMDCMD     ;BNDW/2+FDOP:BNDW:--:--
  001E 3E17           35          MVI     A,PUSHT
  0020 CD0000   E     36          CALL    AMDCMD
  0023 CD0000   E     37          CALL    AMDCMD     ;BNDW/2+FDOP:BNDW/2+FDOP:BNDW/2+FDOP:BNDW
  0026 3E18           38          MVI     A,ROL
  0028 CD0000   E     39          CALL    AMDCMD
  002B CD0000   E     40          CALL    AMDCMD
  002E CD0000   E     41          CALL    AMDCMD     ;BNDW:BNDW/2+FDOP:BNDW/2+FDOP:BNDW/2+FDOP
  0031 3E11           42          MVI     A,FSUB
  0033 CD0000   E     43          CALL    AMDCMD     ;FDOP-BNDW/2:FDOP+BNDW/2:FDOP+BNDW/2:--
  0036 117B00   C     44          LXI     D,TWO
  0039 CD0000   E     45          CALL    GIVE       ;2 ↑
  003C C1             46          POP     B
  003D CD0000   E     47          CALL    AMDLOD     ;SLMDA ↑
  0040 3E13           48          MVI     A,FDIV
  0042 CD0000   E     49          CALL    AMDCMD     ;2/SLMDA:FDOP-BNDW/2:FDOP+BNDW/2:--
  0045 3E17           50          MVI     A,PUSHT
  0047 CD0000   E     51          CALL    AMDCMD     ;2/SLMDA:2/SLMDA:FDOP-BNDW/2:FDOP+BNDW/2
  004A 3E18           52          MVI     A,ROL
  004C CD0000   E     53          CALL    AMDCMD
  004F 3E19           54          MVI     A,EXCHG
  0051 CD0000   E     55          CALL    AMDCMD     ;FDOP-BNDW/2:2/SLMDA:FDOP+BNDW/2:2/SLMDA
  0054 3E13           56          MVI     A,FDIV
  0056 CD0000   E     57          CALL    AMDCMD     ;2/(SLMDA*(FDOP-BNDW/2)):FDOP+BNDW/2:2/SLM
                         DA:--
  0059 3E17           58          MVI     A,PUSHT
  005B CD0000   E     59          CALL    AMDCMD
  005E 3E12           60          MVI     A,FMUL
  0060 CD0000   E     61          CALL    AMDCMD     ;4/(SLMDA*(FDOP-BNDW/2))**2:FDOP+BNDW/2:2/
                         SLMDA/2:--:--
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          XK12     PAGE    2

  LOC  OBJ          LINE        SOURCE STATEMENT

  0063 C1             62         POP     B
  0064 CD0000    E    63         CALL    AMDSTR   ;SAVE RESULT IN XK1
  0067 3E13           64         MVI     A,FDIV
  0069 CD0000    E    65         CALL    AMDCMD   ;2/(SLMDA*(FDOP+BNDW/2))!--!--!--
  006C 3E17           66         MVI     A,PUSHT
  006E CD0000    E    67         CALL    AMDCMD
  0071 3E12           68         MVI     A,FMUL
  0073 CD0000    E    69         CALL    AMDCMD   ;4/(SLMDA*(FDOP+BNDW/2))**2!--!--!--
  0076 C1             70         POP     B
  0077 CD0000    E    71         CALL    AMDSTR   ;SAVE RESULT IN XK2
  007A E9             72         PCHL
                      73         ;
  007B 00             74 TWO:    DB      00H,00H,80H,02H
  007C 00
  007D 80
  007E 02
                      75         END

PUBLIC SYMBOLS
XK12   C 0000

EXTERNAL SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    GET    E 0000    GIVE   E 0000
INTLOD E 0000    INTSTR E 0000

USER SYMBOLS
AMDCMD E 0000    AMDLOD E 0000    AMDSTR E 0000    EXCHG  A 0019    FADD   A 0010
FDIV   A 0013    FMUL   A 0012    FSUB   A 0011    GET    E 0000    GIVE   E 0000
INTLOD E 0000    INTSTR E 0000    PUSHT  A 0017    ROL    A 0018    TWO    C 007B
XK12   C 0000

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ISIS-II ASSEMBLER SYMBOL CROSS REFERENCE, V2.1                  PAGE   1

CMD       12#    16
CNCTL     11#    15     17
IUSART     1
IUSRT      8     14#
MODE      10#    14

CROSS REFERENCE COMPLETE
```

```
ISIS-II ASSEMBLER SYMBOL CROSS REFERENCE, V2.1                    PAGE    1

ASCDV      5     21#
CO        29     66#
CCO       37     44#
CPO       39     41     52#
CP1       46     49     59     61#
CP2       54     57#    68
DC        27     36#
DVERIF     1
GC        25#    33
STP       31#    64     69
STPO      30#    42     50     55     63

CROSS REFERENCE COMPLETE
```

```
ISIS-II ASSEMBLER SYMBOL CROSS REFERENCE, V2.1                    PAGE   1

CO          7      24
GBYT       23#     27
MSGOUT      5      20#
OUTPUT      1
XIT        31      33#

CROSS REFERENCE COMPLETE
```

APPENDIX E

AMC 95/6511 Device Routine Listings

```
ASM80 :F1:AMDCMD.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDCMD    PAGE     1

  LOC  OBJ          LINE         SOURCE STATEMENT

                       1 ;ROUTINE TO SEND A COMMAND IN THE A REGISTER TO THE AMC 95/6011
                       2 ;
                       3 ;             ERRORS ARE TREATED IN THE FOLLOWING MANNER:
                       4 ;                           1) UNDERFLOW            RESULT = 0.0
                       5 ;                           2) OVERFLOW             RESULT ~ +/- 2**63
                       6 ;                           3) DIVIDE BY ZERO       RESULT ~ +/- 2**63
                       7 ;                           4) SQRT OR LOG OF A
                       8 ;                              NEGATIVE NUMBER      RESULT = 0.0
                       9 ;                           5) ARGUMENT OF INVERSE
                      10 ;                              TRIG. OR EXP OUT
                      11 ;                              OF RANGE             RESULT ~ +/- 2**63
                      12 ;
                      13           NAME    AMDCMD
                      14 ;
                      15 ;
  00F0                16 PORT      EQU     00F0H
  0018                17 PULL      EQU     18H
                      18 ;
                      19           PUBLIC  AMDCMD
                      20 ;
                      21           CSEG
                      22 ;
  0000 F5             23 AMDCMD:   PUSH    PSW                ;SAVE COMMAND
  0001 DBF1           24 BZY:      IN      PORT+1             ;WAIT TILL NOT BUSY
  0003 B7             25           ORA     A
  0004 FA0100    C    26           JM      BZY
  0007 F1             27           POP     PSW                ;GET COMMAND
  0008 D3F1           28           OUT     PORT+1             ;SEND COMMAND
  000A F5             29           PUSH    PSW                ;SAVE COMMAND
  000B DBF1           30 BUSY:     IN      PORT+1             ;WAIT TILL NOT BUSY (COMMAND DONE)
  000D B7             31           ORA     A
  000E FA0B00    C    32           JM      BUSY
  0011 D5             33           PUSH    D                  ;SAVE DE REGISTER PAIR
  0012 5F             34           MOV     E,A
  0013 E61E           35           ANI     1EH                ;STRIP OUT ERROR FLAGS
  0015 CA4800    C    36           JZ      NOERR              ;JUMP ON NO ERROR
  0018 3E18           37           MVI     A,PULL
  001A D3F1           38           OUT     PORT+1             ;PULL BAD VALUE OFF AMD STACK
  001C 7B             39           MOV     A,E                ;GET STATUS BACK
  001D E61E           40           ANI     1EH                ;STRIP OUT ERROR FLAGS
  001F FE08           41           CPI     08H                ;SQRT OR LOG OF NEG NUMBER = UNDFLO
  0021 CA3E00    C    42           JZ      UNDFLO
  0024 E604           43           ANI     04H                ;UNDERFLOW
  0026 C23E00    C    44           JNZ     UNDFLO
  0029 3EFF           45           MVI     A,0FFH             ;TREAT ALL OTHER ERRORS AS OVERFLOW
  002B 1603           46           MVI     D,03
  002D D3F0           47 LOOP:     OUT     PORT
  002F 15             48           DCR     D
  0030 C22D00    C    49           JNZ     LOOP
  0033 7B             50           MOV     A,E                ;GET ERROR FLAGS
  0034 17             51           RAL                        ;GET SIGN
  0035 E680           52           ANI     80H
  0037 F63F           53           ORI     3FH                ;MAKE MAX EXP WITH PROPER SIGN
  0039 D3F0           54           OUT     PORT               ;SEND TO BOARD
```

```
ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDCMD   PAGE    2

  LOC  OBJ          LINE        SOURCE STATEMENT

  003B C34800   C     55           JMP     NOERR
  003E 3E00           56 UNDFLO:   MVI     A,00H            ;UNDERFLOW, THEN SEND ZERO TO THE BOARD
  0040 1604           57 MVI       D,04
  0042 D3F0           58 LOOP2:    OUT     PORT
  0044 15             59           DCR     D
  0045 C24200   C     60           JNZ     LOOP2
  0048 D1             61 NOERR:    POP     D
  0049 F1             62           POP     PSW
  004A C9             63           RET
                      64           END

PUBLIC SYMBOLS
AMDCMD C 0000

EXTERNAL SYMBOLS


USER SYMBOLS
AMDCMD C 0000     BUSY   C 000B     BZY    C 0001     LOOP   C 002D     LOOP2  C 0042     NOERR  C 0048
   PORT   A 00F0
PULL   A 0018     UNDFLO C 003E

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:AMDSTR.SRC DEBUG


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDSTR    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                          ;ROUTINE TO STORE A FLOATING POINT NUMBER (IN INTEL FORMAT)
                          ; FROM THE AMC 95/6011 INTERNAL REGISTER AT THE ADDRESS IN BC
                          ;
                          ;                   ERRORS ARE TREATED IN THE FOLLOWING MANNER:
                          ;                             1) UNDERFLOW             RESULT = 0.0
                          ;                             2) OVERFLOW              RESULT ~ +/- 2**127
                          ;                             3) DIVIDE BY ZERO        RESULT ~ +/- 2**127
                          ;                             4) SQRT OR LOG OF A
                          ;                                NEGATIVE NUMBER       RESULT = 0.0
                          ;                             6) ARGUMENT OF INVERSE
                          ;                                TRIG. OR EXP OUT
                          ;                                OF RANGE              RESULT ~ +/- 2**127
                          ;
                                  NAME    AMDSTR
                          ;
                          ;
  00F0                    PORT    EQU     00F0H
  0018                    PULL    EQU     18H
                          ;
                                  PUBLIC  AMDSTR
                          ;
                                  CSEG
                          ;
  0000 D5                 AMDSTR: PUSH    D                   ;SAVE DE REGISTER PAIR
  0001 03                         INX     B                   ;MOVE POINTER TO BEGINNING
  0002 03                         INX     B
  0003 03                         INX     B
  0004 DBF1               BUSY:   IN      PORT+1              ;WAIT TILL NOT BUSY
  0006 B7                         ORA     A
  0007 FA0400      C              JM      BUSY
  000A 5F                         MOV     E,A
  000B E61E                       ANI     1EH                 ;CHECK FOR ERROR
  000D CA3800      C              JZ      NOERR
  0010 3E18                       MVI     A,PULL              ;PULL BAD ENTRY OFF AMD STACK
  0012 D3F1                       OUT     PORT+1
  0014 7B                         MOV     A,E                 ;GET STATUS BACK
  0015 E61E                       ANI     1EH                 ;STRIP OUT ERROR FLAGS
  0017 FE08                       CPI     08H                 ;SQRT OR LOG OF A NEGATIVE NUMBER = UNDFLO
  0019 CA3200      C              JZ      UNDFLO
  001C E604                       ANI     04H                 ;UNDERFLO
  001E C23200      C              JNZ     UNDFLO
  0021 7B                         MOV     A,E                 ;GET ERROR FLAGS
  0022 17                         RAL
  0023 E680                       ANI     80H
  0025 F67F                       ORI     7FH                 ;MAKE MAX EXPONENT WITH PROPER SIGN
  0027 02                         STAX    B
  0028 3EFF                       MVI     A,0FFH              ;SAVE MANTISSA
  002A 0B                 BACK:   DCX     B
  002B 02                         STAX    B
  002C 0B                         DCX     B
  002D 02                         STAX    B
  002E 0B                         DCX     B
  002F 02                         STAX    B
  0030 D1                         POP     D                   ;RESTORE DE REGISTER PAIR
  LOC  OBJ         LINE        SOURCE STATEMENT

 0031 C9             55         RET
 0032 3E00           56 UNDFLO: MVI     A,00H           ;UNDERFLOW, THEN RESULT = 0.0
 0034 02             57         STAX    B
 0035 C32A00    C    58         JMP     BACK
 0038 DBF0           59 NOERR:  IN      PORT            ;GET BYTE 3 (EXPONENT)
 003A 07             60         RLC                     ;CONVERT EXPONENT TO INTEL FORMAT
 003B B7             61         ORA     A
 003C F24500    C    62         JP      SKIP1
 003F C6FC           63         ADI     0FCH
 0041 3F             64         CMC
 0042 C34700    C    65         JMP     SKIP2
 0045 C6FC           66 SKIP1:  ADI     0FCH
 0047 1F             67 SKIP2:  RAR
 0048 1F             68         RAR
 0049 02             69         STAX    B               ;SAVE BYTE 3
 004A DBF0           70         IN      PORT            ;GET BYTE 2
 004C 17             71         RAL                     ;REPLACE MSB WITH EXPONENT LSB
 004D 0F             72         RRC
 004E 0B             73         DCX     B
 004F 02             74         STAX    B               ;SAVE BYTE 2
 0050 DBF0           75         IN      PORT            ;GET BYTE 1
 0052 0B             76         DCX     B
 0053 02             77         STAX    B               ;SAVE BYTE 1
 0054 DBF0           78         IN      PORT            ;GET BYTE 0
 C056 0B             79         DCX     B
 0057 02             80         STAX    B               ;SAVE BYTE 0
 0058 D1             81         POP     D               ;RESTORE DE RESISTER PAIR
 0059 C9             82         RET
                     83         END

PUBLIC SYMBOLS
AMDSTR C 0000

EXTERNAL SYMBOLS


USER SYMBOLS
AMDSTR C 0000    BACK    C 002A    BUSY    C 0004    NOERR   C 0038    PORT    A 00F0    PULL    A 0018
    SKIP1   C 0045
SKIP2  C 0047    UNDFLO C 0032

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:AMDLOD.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          AMDLOD    PAGE     1

  LOC  OBJ          LINE         SOURCE STATEMENT

                       1 ;ROUTINE TO LOAD A FLOATING POINT NUMBER (IN INTEL FORMAT) FROM
                       2 ; THE ADDRESS IN BC INTO THE AMC 95/6011 INTERNAL REGISTER
                       3 ;
                       4           NAME    AMDLOD
                       5 ;
                       6 ;
  00F0                 7 PORT      EQU     00F0H
                       8 ;
                       9           PUBLIC  AMDLOD
                      10 ;
                      11           CSEG
                      12 ;
  0000 DBF1           13 AMDLOD:   IN      PORT+1             ;READ STATUS
  0002 B7             14           ORA     A                  ;SET FLAGS
  0003 FA0000    C    15           JM      AMDLOD             ;LOOP IF BUSY
  0006 0A             16           LDAX    B
  0007 D3F0           17           OUT     PORT               ;SEND BYTE 0
  0009 03             18           INX     B
  000A 0A             19           LDAX    B
  000B D3F0           20           OUT     PORT               ;SEND BYTE 1
  000D 03             21           INX     B
  000E 0A             22           LDAX    B                  ;GET BYTE 2
  000F F680           23           ORI     80H                ;SET MSB
  0011 D3F0           24           OUT     PORT               ;SEND
  0013 0A             25           LDAX    B                  ;GET BYTE 2
  0014 17             26           RAL                        ;MOVE SIGN TO CARRY
  0015 03             27           INX     B
  0016 0A             28           LDAX    B                  ;GET BYTE 3
  0017 17             29           RAL                        ;SHIFT IN EXPONENT LSB
  0018 17             30           RAL                        ;BEGIN CONVERTING EXPONENT
  0019 DA2800    C    31           JC      LABEL1
  001C FE7C           32           CPI     7CH                ;EXP>=2**-65
  001E D23400    C    33           JNC     LABEL2
  0021 1F             34           RAR
  0022 3E80           35           MVI     A,80H              ;IF NOT EXP=2**-65
  0024 1F             36           RAR
  0025 C33700    C    37           JMP     LABEL3
  0028 FE7C           38 LABEL1:   CPI     7CH                ;EXP<2**63
  002A DA3400    C    39           JC      LABEL2
  002D 1F             40           RAR
  002E 3E7E           41           MVI     A,7EH              ;IF NOT EXP=2**62
  0030 1F             42           RAR
  0031 C33700    C    43           JMP     LABEL3
  0034 C604           44 LABEL2:   ADI     04                 ;COMPLETE CONVERTING EXPONENT
  0036 0F             45           RRC
  0037 D3F0           46 LABEL3:   OUT     PORT               ;SEND EXPONENT(BYTE 3)
  0039 C9             47           RET                        ;RETURN
                      48           END

 PUBLIC SYMBOLS
 AMDLOD C 0000

 EXTERNAL SYMBOLS


 USER SYMBOLS
 AMDLOD C 0000    LABEL1 C 0028    LABEL2 C 0034    LABEL3 C 0037    PORT    A 00F0

 ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:INTSTR.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          INTSTR    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                      1 ;ROUTINE TO STORE A 16-BIT INTEGER AT THE ADDRESS IN BC
                      2 ;  FROM THE 95/6011 INTERNAL REGISTER
                      3 ;
                      4         NAME    INTSTR
                      5 ;
                      6 ;
  00F0                7 PORT    EQU     00F0H
                      8 ;
                      9         PUBLIC  INTSTR
                     10 ;
                     11         CSEG
                     12 ;
  0000 DBF1          13 INTSTR: IN      PORT+1          ;WAIT TILL NOT BUSY
  0002 B7            14         ORA     A
  0003 FA0000    C   15         JM      INTSTR
  0006 03            16         INX     B
  0007 DBF0          17         IN      PORT
  0009 02            18         STAX    B               ;SAVE BYTE 1
  000A 0B            19         DCX     B
  000B DBF0          20         IN      PORT
  000D 02            21         STAX    B               ;SAVE BYTE 0
  000E C9            22         RET
                     23         END

PUBLIC SYMBOLS
INTSTR C 0000

EXTERNAL SYMBOLS


USER SYMBOLS
INTSTR C 0000    PORT    A 00F0

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:GIVE.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         GIVE     PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1 ;ROUTINE TO GIVE A FLOATING POINT NUMBER (IN AMD FORMAT) AT THE
                       2 ; ADDRESS IN DE TO THE AMC 95/6011 INTERNAL REGISTER
                       3 ;
                       4          NAME    GIVE
                       5 ;
                       6 ;
  00F0                 7 PORT     EQU     00F0H
                       8 ;
                       9          PUBLIC  GIVE
                      10 ;
                      11          CSEG
                      12 ;
  0000 DBF1           13 GIVE:    IN      PORT+1          ;WAIT TILL NOT BUSY
  0002 B7             14          ORA     A
  0003 FA0000    C    15          JM      GIVE
  0006 1A             16          LDAX    D
  0007 D3F0           17          OUT     PORT            ;SEND BYTE 0
  0009 13             18          INX     D
  000A 1A             19          LDAX    D
  000B D3F0           20          OUT     PORT            ;SEND BYTE 1
  000D 13             21          INX     D
  000E 1A             22          LDAX    D
  000F D3F0           23          OUT     PORT            ;SEND BYTE 2
  0011 13             24          INX     D
  0012 1A             25          LDAX    D
  0013 D3F0           26          OUT     PORT            ;SEND BYTE 3
  0015 1B             27          DCX     D
  0016 1B             28          DCX     D
  0017 1B             29          DCX     D
  0018 C9             30          RET
                      31          END

PUBLIC SYMBOLS
GIVE   C 0000

EXTERNAL SYMBOLS


USER SYMBOLS
GIVE   C 0000    PORT    A 00F0

ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:GET.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0          GET       PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                       1 ;ROUTINE TO GET A FLOATING POINT NUMBER (IN AMD FORMAT) FROM THE
                       2 ; AMC 95/6011 INTERNAL REGISTER AND STORE IT AT THE ADDRESS IN DE
                       3 ;
                       4          NAME    GET
                       5 ;
                       6 ;
  00F0                 7 PORT     EQU     00F0H
                       8 ;
                       9          PUBLIC  GET
                      10 ;
                      11          CSEG
                      12 ;
  0000 13             13 GET:     INX     D               ;MOVE POINTER
  0001 13             14          INX     D
  0002 13             15          INX     D
  0003 DBF1           16 BSY:     IN      PORT+1          ;WAIT TILL NOT BUSY
  0005 B7             17          ORA     A
  0006 FA0300    C    18          JM      BSY
  0009 DBF0           19          IN      PORT
  000B 12             20          STAX    D               ;SAVE BYTE 3
  000C 1B             21          DCX     D
  000D DBF0           22          IN      PORT
  000F 12             23          STAX    D               ;SAVE BYTE 2
  0010 1B             24          DCX     D
  0011 DBF0           25          IN      PORT
  0013 12             26          STAX    D               ;SAVE BYTE 1
  0014 1B             27          DCX     D
  0015 DBF0           28          IN      PORT
  0017 12             29          STAX    D               ;SAVE BYTE 0
  0018 C9             30          RET
                      31          END

 PUBLIC SYMBOLS
 GET    C 0000

 EXTERNAL SYMBOLS


 USER SYMBOLS
 BSY    C 0003    GET    C 0000    PORT   A 00F0

 ASSEMBLY COMPLETE,   NO ERRORS
```

```
ASM80 :F1:INTLOD.SRC DEBUG PAGELENGTH(75) PAGEWIDTH(90)


ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         INTLOD    PAGE    1

  LOC  OBJ          LINE        SOURCE STATEMENT

                      1 ;ROUTINE TOL LOAD A 16-BIT INTEGER AT THE ADDRESS IN BC INTO
                      2 ;  THE AMC 95/6011 INTERNAL REGISTER
                      3 ;
                      4           NAME    INTLOD
                      5 ;
                      6 ;
  00F0                7 PORT      EQU     00F0H
                      8 ;
                      9           CSEG
                     10 ;
                     11           PUBLIC  INTLOD
                     12 ;
  0000 DBF1          13 INTLOD:   IN      PORT+1          ;WAIT TILL NOT BUSY
  0002 B7            14           ORA     A
  0003 FA0000    C   15           JM      INTLOD
  0006 0A            16           LDAX    B
  0007 D3F0          17           OUT     PORT            ;SEND BYTE 0
  0009 03            18           INX     B
  000A 0A            19           LDAX    B
  000B D3F0          20           OUT     PORT            ;SEND BYTE 1
  000D C9            21           RET
                     22           END

PUBLIC SYMBOLS
INTLOD C 0000

EXTERNAL SYMBOLS

USER SYMBOLS
INTLOD C 0000    PORT    A 00F0

ASSEMBLY COMPLETE,    NO ERRORS
```

```
ASM80 :F1:I32LOD.SRC DEBUG PAGELENGTH(75)

ISIS-II 8080/8085 MACRO ASSEMBLER, V3.0         I32LOD    PAGE    1

  LOC  OBJ         LINE        SOURCE STATEMENT

                      1 ;ROUTINE TO LOAD A 32-BIT INTEGER NUMBER AT THE ADDRESS IN BC INTO
                      2 ; THE AMD 95/6011 INTERNAL REGISTER. BC IS INCREMENTED BY FOUR.
                      3 ;
                      4          NAME    I32LOD
                      5 ;
                      6 ;
  00F0                7 PORT     EQU     00F0H
                      8 ;
                      9          PUBLIC  I32LOD
                     10 ;
                     11          CSEG
                     12 ;
  0000 DBF1          13 I32LOD:  IN      PORT+1          ;WAIT TILL NOT BUSY
  0002 B7            14          ORA     A
  0003 FA0000   C    15          JM      I32LOD
  0006 03            16          INX     B
  0007 03            17          INX     B
  0008 03            18          INX     B
  0009 0A            19          LDAX    B
  000A D3F0          20          OUT     PORT            ;SEND BYTE 0
  000C 0B            21          DCX     B
  000D 0A            22          LDAX    B
  000E D3F0          23          OUT     PORT            ;SEND BYTE 1
  0010 0B            24          DCX     B
  0011 0A            25          LDAX    B
  0012 D3F0          26          OUT     PORT            ;SEND BYTE 2
  0014 0B            27          DCX     B
  0015 0A            28          LDAX    B
  0016 D3F0          29          OUT     PORT            ;SEND BYTE 3
  0018 03            30          INX     B
  0019 03            31          INX     B
  001A 03            32          INX     B
  001B 03            33          INX     B
  001C C9            34          RET
                     35          END

PUBLIC SYMBOLS
I32LOD C 0000

EXTERNAL SYMBOLS

USER SYMBOLS
I32LOD C 0000    PORT    A 00F0

ASSEMBLY COMPLETE,    NO ERRORS
```