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NORTHROP CORP HAWTHORNE CALIF ELECTRONICS DIV
AN/BRN-7 COMPUTER PROGRAM SPECIFICATION. VOLUME V. TRACKING FIL--ETC(U)
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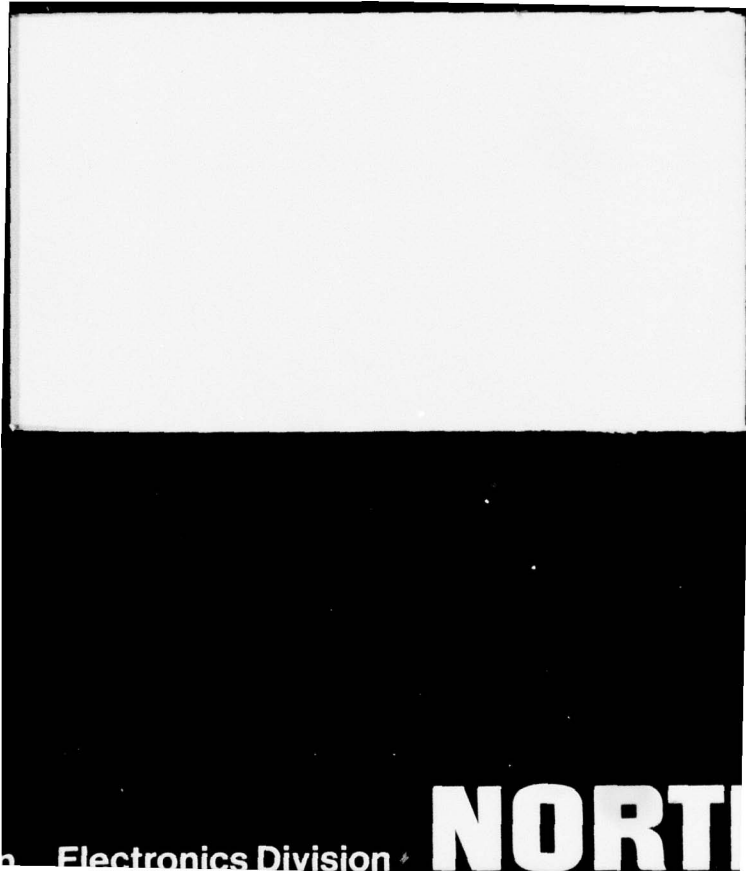
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<input type="checkbox"/>	This submittal applies to AN/SRN-() (Hydrofoil Ω) only.
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NORT 73-48
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**AN/BRN-7 COMPUTER
PROGRAM SPECIFICATION**

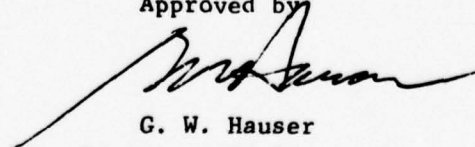
Volume V

TRACKING FILTER SUBPROGRAM DESIGN

October 12, 1973

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G. W. Hauser
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Navigation Department

Volume V
of the
AN/BRN-7 OMEGA COMPUTER
PROGRAM SPECIFICATION

Volume

- I Performance Specification
- II Design Specification
- III Synchronization Subprogram Design
- IV OMEGA Processing Subprogram Design
- V Tracking Filter Subprogram Design
- VI Kalman Filter Subprogram Design
- VII Propagation Prediction Subprogram Design
- VIII Navigation Subprogram Design
- IX Executive Subprogram Design
- X Control-Indicator Subprogram Design
- XI Built-in Test Subprogram Design
- XII Common Subroutines Subprogram Design
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SECTION 1

SCOPE

1.1 IDENTIFICATION

Volume I, Submarine OMEGA Computer Program Performance Specification, defines the functional requirements for the Submarine OMEGA Computer Program which is used by the AN/ARN-99 OMEGA Navigation Set. The Navigation Set and the OMEGA program together comprise the Submarine OMEGA Navigation System. The tape which defines the computer program is entitled AN/BRN 7 Navigation Program.

Volume II, Submarine OMEGA Computer Program Design Specification, allocated the functional requirements of Volume I to the computer routine and subprogram level.

This volume describes the subprogram designated as Tracking Filter, which has the abbreviation TF in the program listing (Volume XIII).

1.2 TRACKING FILTER SUBPROGRAM TASKS (Figure 1)

- a) Initialization/Reinitialization: The procedures for initialization and reinitialization are used at start-up, when the velocity sources for the calculations are changed; whenever a change in the base station is indicated, or whenever initial time or initial position is inserted. The operations involved include combinations of: setting the n-counters to zero, and resetting the phase-difference variances, the phase-difference rate variances, and the cross-variances.
- b) Time Updating of Variance: All Tracking Filters are time updated at the end of every OMEGA burst. This includes the variance on the phase-difference estimate, and if this is too large then the cross-variance is also reset. Similarly the variance on the phase-difference rate is time updated, and if too large, then again the cross-variance is reset.
- c) Time Updating of Phase Rate: Phase Rate is time updated after the variance time update for each station-to-base pair. Using station coordinates and velocity components, the phase rate for the base is calculated and this, in turn, will be used to correct the phase rate on the station-to-base phase-rate estimate.
- d) Time Updating of Phase Estimate: The phase difference estimate is iterated once for each station and base station combination at the end of each burst (24 times in a 10-second cycle).

TRACKING FILTER

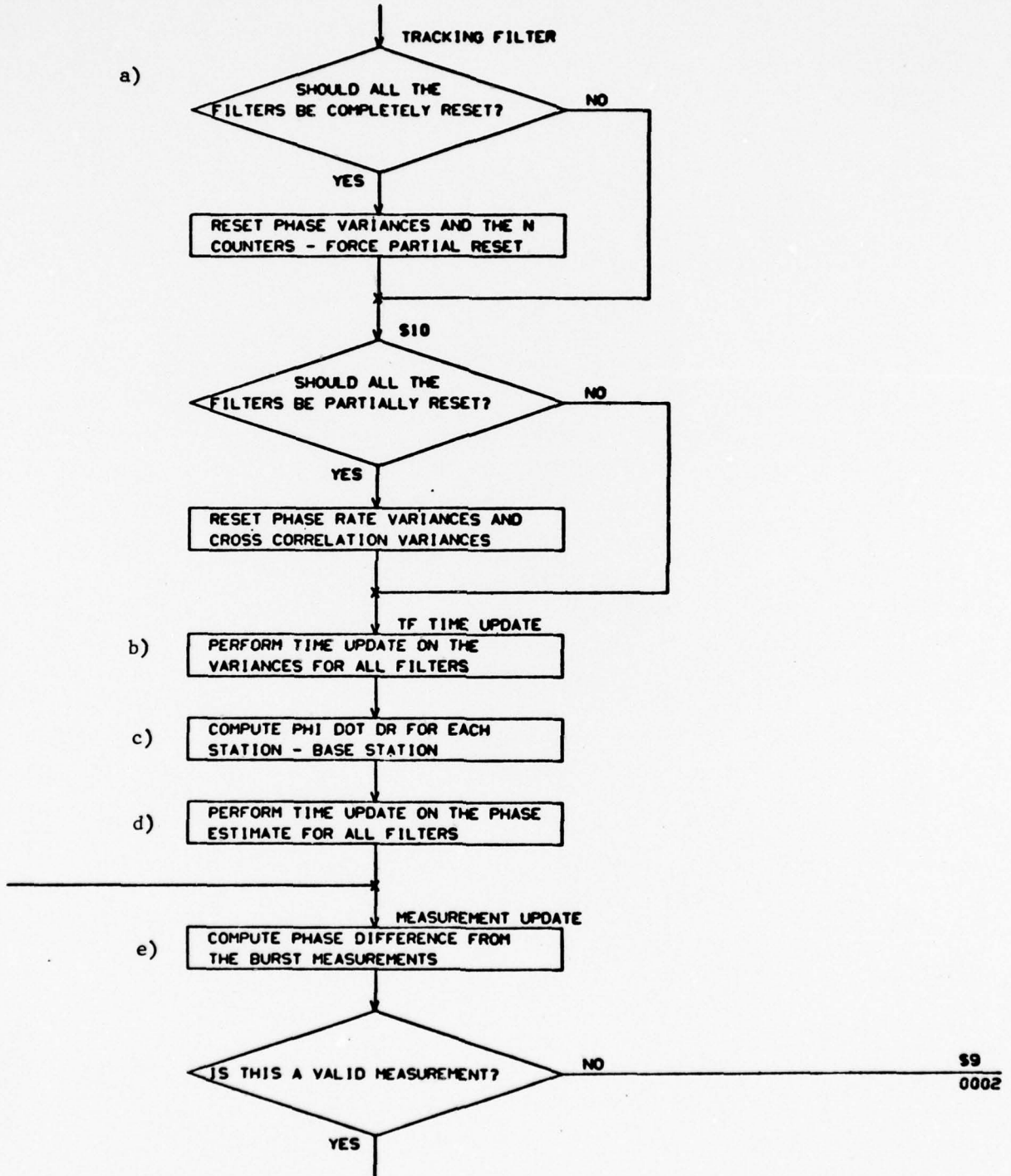


FIGURE 1 (Sheet 1)

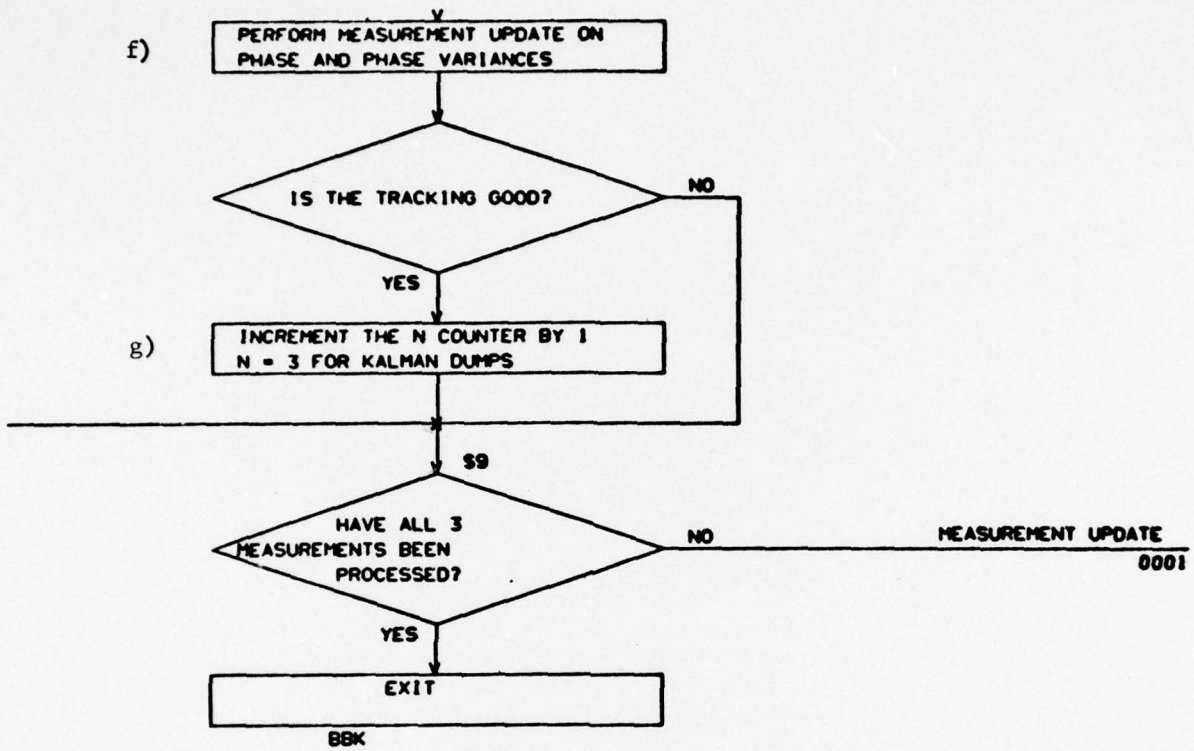


FIGURE 1 (Sheet 2)

- e) Phase Differencing: Using RAW H, which is the three-frequency burst element from END BURST, determine whether to light the SIGNAL LOSS indicator, and then smooth RAW H with previous data. Difference the burst phase with that from the station designated as base, then add their variances. Or if the present station is the base station then save for base station phase rate updating.
- f) Measurement Update: A measurement update occurs if the variance from the phase differencing process is less than one square cycle. The difference between the estimate of phase difference and raw measurement from the OMEGA PROCESSING routine is used to make the filter adaptive; the variances increase in proportion to the amount of disagreement.
- The correction term, θ , must be calculated. The phase-difference rate variance is measurement updated, and then the phase-difference estimate is measurement updated, as well as its variance.
- g) Increment n-Counters: Test the variance on the phase-estimate and phase-difference rate estimate. If within the criteria, set the increment n-counters.

SECTION 2

APPLICABLE DOCUMENTS

- a) Submarine OMEGA Computer Program Performance Specification, Volume I of the Submarine OMEGA Computer Program Specification.

Applicable Sections:

- 3.1 Introduction
 - 3.2 Functional Description
 - 3.2.5 Detailed System Operations
 - 3.3 Detailed Functional Requirements
 - 3.3.8 Base Station Selection
 - 3.3.9 Phase Difference Function
 - 3.3.10 Tracking Filters
- b) Submarine OMEGA Computer Program Design Specification, Volume II of the Submarine OMEGA Computer Program Specification.
- 3.3 Subprogram Description and Allocation of Requirements
- c) NORT 68-66, NAP70 User's Manual, July 1968.
- d) NORT 68-115A, Detailed Description of NDC-1070 Computer Instructions, Revision A, February 1970.
- e) NORT 69-87A, NDC-1070 Flow Chart Program, User's Manual.

NOTE: The data base for each subprogram is included in the appropriate volume.

SECTION 3

REQUIREMENTS

In order to understand the program description contained in the following pages, it is necessary that the reader will have become familiar with the associated functional requirements found in Volume I, Performance Specification, and with the subprogram allocation found in Volume II, Design Specification.

3.1 DETAILED DESCRIPTION

3.1.1 Reference Labels to Flow Diagrams

The code used to reference the particular block in the flow diagrams, Section 3.2, is as follows: The first number, preceded by a p, is the page number found in the upper right corner of the diagrams. This will be followed by a slash sign (/) to separate the page number from the block designator. The designator will either be a mnemonic label (e.g., TEST SYNC), a local label indicated by a dollar sign (\$), or an integer. The two types of labels reference the particular information block, on the given page, to which the label is attached. The integer number, n, means that the referenced block is the nth block from the top of the page; p8/3 would refer to page 8 and the third information block down.

Finally, the label P1/\$2+3 refers to page 1, and the 3rd information block after the label \$2. Similarly, P2/7,8,9 refers to Page 2 and blocks 7 through 9.

3.1.2 Overview

It is desirable to further process the measurements from OMEGA PROCESSING in order to develop more accurate and usable values. This is accomplished in the Tracking Filters. Successive phase measurements from OMEGA PROCESSING for each transmitting station and each frequency are combined in separate Tracking Filters. Since there are 8 possible transmitting stations and 3 frequencies processed in the receiver, there are 24 Tracking Filters.

Each Tracking Filter receives an input from OMEGA PROCESSING every 10 seconds. This input consists of a measure of phase and a computed variance of this measurement. The Submarine OMEGA Navigation System uses a hyperbolic navigation concept. Consequently, each burst phase from station i is combined with the last incoming burst phase from the station designated as the base station, and usually subscripted by k. The result of this is a measurement of phase difference. This measured phase difference ϕ_{ik} (freq) is then compared (or weighted in a statistical sense) with an

estimated value of phase $\hat{\phi}_{ik}$ (freq) which the Tracking Filter computes based upon previous measurements. From this comparison a new estimate of phase is computed.

Henceforth the frequency dependence of the symbols will be dropped for convenience, so that ϕ_{ik} (freq) will be represented as ϕ_{ik} . It is understood that the operations involved apply to not one but three frequencies.

In order to compare or statistically average successive phase difference measurements spaced 10 seconds apart in time, it is necessary to remove the effect of the change in phase due to the submarine change in position. This is referred to as rate-aiding. Velocity information is obtained from a velocity source external to the OMEGA receiver (E.M. Log Repeater or manual insert). The velocity inputs to the Tracking Filter consist of the V_2 and V_3 components of the raw velocity as computed by the velocity processing equation. OMEGA velocity corrections are not used in Tracking Filters. The Tracking Filter then computes the component of velocity along the direction from submarine to transmitting station, then to the base station, and then converts to an equivalent dead reckoning phase rate, $\dot{\phi}_{DR}$. This phase rate is then used to update the Tracking Filter phase-difference estimate $\hat{\phi}$.

Besides estimating phase differences, the Tracking Filter also estimates phase-difference rate error, $\Delta\dot{\phi}$. This is the error in phase rate as computed from the velocity sources. The estimated phase-difference rate error $\Delta\dot{\phi}$ is used to correct the computed phase-difference rate $\dot{\phi}_{DR}$ in the time update of the estimate.

In addition to computing $\hat{\phi}$ and $\Delta\dot{\phi}$, the Tracking Filter also computes the following variances:

- a) $\sigma_{\phi\phi}^2$, the variance of the error in estimating phase-difference
- b) $\sigma_{\dot{\phi}\dot{\phi}}^2$, the variance of the error in estimating phase-difference rate error
- c) $\sigma_{\phi\dot{\phi}}^2$, the cross-variance of errors in estimating both.

It is the computation of these variances along with σ_{ik}^2 from burst measurements that allows the filter to statistically average ϕ_{ik} and $\dot{\phi}_{ik}$ and obtain better estimates of $\hat{\phi}_{ik}$ and $\Delta\dot{\phi}_{ik}$. The three variances listed above are updated and recomputed at every phase measurement.

The outputs of the Tracking Filters are $\hat{\phi}$, $\sigma_{\phi\phi}^2$ (station and base subscripts omitted) for each station-base or base-base pair. These outputs are the inputs to the Combinational Filter. The Combinational Filter combines the outputs of the Tracking Filters to obtain position estimates. When $\sigma_{\phi\phi}^2$ has reached a value of less than 3 cec² and $\sigma_{\dot{\phi}\dot{\phi}}^2$ is less than (0.03 cec/sec)² for three consecutive Burst Filter measurements, the phase

estimate is considered accurate enough to be used by the Combinational Filter. A counter (called the n counter) is used as a flag to tell the Combinational Filter when to read the Tracking Filter outputs.

With every phase difference measurement the counter is incremented if $\sigma^2_{\phi\phi}$ and $\sigma^2_{\dot{\phi}\dot{\phi}}$ are both less than their respective limits, otherwise the counter is reset to zero. When the counter reaches three, the Tracking Filter is ready to be read. The Combinational Filter will then read the $\hat{\phi}$ and $\sigma^2_{\phi\phi}$ from the Tracking Filter. Until the Tracking Filter outputs are read the Tracking Filter continues to operate in a normal manner. When the outputs are read, the n counter is reset to zero and the Tracking Filter is reset. It is desirable for each reading from a given Tracking Filter to be statistically independent from the others. For this reason, the Tracking Filter variances are reset to their initial values after being read by the Combinational Filter. These values assure independence of Tracking Filter outputs.

The statistical derivation of the Tracking Filter equations is given in Appendix A, Volume I.

3.1.3 Description of Flow Diagrams

The following description is by the task sequence outlined in 1.2.

The Submarine OMEGA Computer Program Functional Requirements were defined in Volume I, Performance Specification, and allocated to Subprograms in Volume II, Design Specification. The Tracking Filter Subprogram has combined portions of these requirements. Those affected are summarized here.

<u>Paragraph in this section</u>	<u>Functional Requirement</u>
e 1)	3.3.8 Base Station Selection item 3.3.8.3.1-c 3.3.8.3.2-b
e 2)	3.3.9 Phase Difference Function
All others	3.3.10 Tracking Filter Requirement
a) <u>Initialization/Reinitialization</u>	
p1/Tracking Filter	
to	
p2/TF Time Update	

- 1) The Initialization/Reinitialization procedures are used:
 - a. At start-up
 - b. When the velocity sources for the calculations are changed
 - c. When the Combinational (Kalman) Filter uses a Tracking Filter output (See note for 1c, below)
 - d. Whenever a change in the base station is indicated
 - e. Whenever initial time or initial position is entered.

2) The procedures for the above are as follows:

- a. Set all n-counters to zero
- b. Set $\sigma_{\phi\phi}^2 = \frac{1}{12}$
- c. Set $\sigma_{\dot{\phi}\dot{\phi}}^2 = 0$
- d. Set $\sigma_{\dot{\phi}\dot{\phi}}^2 = (0.006 \pi)^2$

For 1a; 1d; 1e, reset all tracking filters by 2a through 2d.

For 1b, reset all tracking filters by 2c and 2d.

For 1c, reset only the selected filter, using 2a through 2d.

NOTE: For 1c, the Combinational Filter resets only the selected filter and effectively accomplishes 2a through 2d, but does not use the Tracking Filter reinitialization procedures.

b) Time Updating of Variance

p2/TF Time Update

to

P3/§3 + 5

All Tracking Filters are time updated at the end of every OMEGA burst. The following equations are computed in the order indicated.

$$1) \sigma_{\phi\phi}^2(k) = \sigma_{\phi\phi}^2(k-1) + 2 \sigma_{\dot{\phi}\dot{\phi}}^2(k-1) \Delta t_k + \sigma_{\dot{\phi}\dot{\phi}}^2(k-1) (\Delta t_k)^2$$

$$\text{Test: } \text{is } \sigma_{\phi\phi}^2(k) > 1 \text{ (cycle)}^2$$

Yes. Then set $\sigma_{\phi\phi}^2(k) = 1 \text{ (cycle)}^2$

$$\sigma_{\phi\phi}^2(k) = \sigma_{\phi\phi}^2(k-1)/2$$

go to (2)

No. Then $\sigma_{\phi\phi}^2(k) = \sigma_{\phi\phi}^2(k-1) + \sigma_{\phi\phi}^2(k-1) \Delta t_k$

$$2) \sigma_{\phi\phi}^2(k) = \sigma_{\phi\phi}^2(k-1) + r^2$$

$$\text{Test: is } \sigma_{\phi\phi}^2(k) > \frac{1}{2\pi^2} \left(\frac{\text{cycle}}{\text{sec}} \right)^2$$

Yes. Then set $\sigma_{\phi\phi}^2 = \frac{1}{2\pi^2}$

$$\sigma_{\phi\phi}^2(k) = \frac{\sigma_{\phi\phi}^2(k)}{2}$$

and continue.

No. Then continue.

c) Time Update of Phase Rate

p4/\$1 to p6/\$6

Processed after variance update for each station and base-station pair.

- 1) Station coordinates; earth fixed to local level coordinates. Obtain for station and base.

$$SL_{2i} = \sum_{f=1}^3 r_{2f} S_{fi}$$

$$SL_{3i} = \sum_{f=1}^3 r_{3f} S_{fi}$$

$i = 1, \dots 8$ (station)

r_{ij} = Element in the i^{th} row and j^{th} column of the R_{ij} matrix from which vehicle position is computed.

- 2) $\dot{\phi}_{DR}$ Determination; obtain $\dot{\phi}_{DR}$ (station) and $\dot{\phi}_{DR}$ (base)

$$\dot{\phi}_{DR_{ii}} = \frac{V_3 SL_{3i} + V_2 SL_{2i}}{\left(SL_{3i}^2 + SL_{2i}^2 \right)^{1/2}}$$

Since the filters are tracking an angle that represents the phase of station i at time t minus the phase of the base station at some earlier time, it is necessary to make the following correction for arrival at the final value of $\dot{\phi}_{DR}$ for each Tracking Filter:

$$\dot{\phi}_{DR_{ik}} = \dot{\phi}_{DR_{ii}}(t) - \dot{\phi}_{DR_{kk}}(t-t')$$

where i = station number
 j = frequency
 k = base station number
 t = time
 t' = time delay between base station burst and station i burst for this frequency (if $i=k$ then $t-t'=10$ sec)

For computational purposes it would be adequate to set $t' = 0$ in all cases.

d) Time Update of Phase Estimate

p6/\$2 to p6/Measurement Update

The phase difference estimate is iterated once for each station and base station combination at the end of each burst (24 times in a 10-second cycle).

$$\hat{\phi}(k) = \hat{\phi}(k-1) + \Delta t_u \left[\frac{\lambda_3}{\lambda_1} \dot{\phi}_{DR}(k) + \hat{\Delta\phi}(k-1) \right]$$

where Δt_u = time period since last update.

If Δt_b is interval of previous burst then

$$\Delta t_u = \Delta t_b + 0.4 \text{ sec.}$$

e) Phase Differencing

p6/Measurement Update to p10/\$21 + 1

- 1) For station i, obtain RH_i from OMEGA Processing
(= $Q_{mi}(f_1) Q_{mi}(f_2) Q_{mi}(f_3)$).

Perform a simple smoothing operation on resultant

$$SRH_i = SRH_i + 0.1 (RH_i - SRH_i)$$

If $SRH_{base} \leq 0.0078125$ then set SIG LOSS marker and continue normal operation, otherwise continue.

- 2) Phase Difference Calculation: The following procedures, though indicated for one input only, are done three times per each burst period; 24 per 10-second OMEGA cycle.

Determine station and frequency of input. Is input phase measurement from base station? (check BASE)

No. Then difference input phase measurement ϕ_a with last stored base station phase value ϕ_b , where ϕ_i represent the ϕ_m value from station i on the associated frequency; from burst processing.

$$\phi_{ab} = \phi_a - \phi_b$$

Then combine the associated variances as indicated.

$$\sigma_{ab}^2 = \sigma_a^2 + \sigma_b^2$$

where σ_i^2 represents $\sigma_{\phi_m}^2$ station i on associated frequency; from burst processing.

Yes. Then difference input base station measurement with last stored base station phase value. Combine the variances as indicated.

$$\begin{aligned}\phi_{bb} &= \phi_b(\text{input}) - \phi_b(\text{stored}) \\ \sigma_{bb}^2 &= \sigma_{bb}^2(\text{input}) + \sigma_{bb}^2(\text{stored})\end{aligned}$$

Then replace reference base station phase value and variance with input values.

f) Measurement Update

p11/1 to 3

A measurement update is permitted to occur if the variance from OMEGA Processing is less than one square cycle. The difference between the estimate of phase difference, $\hat{\phi}$, and the raw measurement, ϕ_{ik} , is used to make the filter adaptive; the variances increase in proportion to the amount of disagreement. Since ϕ_{ik} is a value averaged over the time interval Δt_u while $\hat{\phi}$ is updated by rate aiding to the end of the time interval, $\hat{\phi}$ is adjusted to make it correspond to near the middle of the interval. This explains the correction term in the equation for the angular difference θ .

1) Angular Difference Correction

$$\theta = \phi_m - \hat{\phi} + \left[\frac{\lambda_3}{\lambda_i} \dot{\phi}_{DR} + \Delta \dot{\phi} \right] \quad (0.425)$$

(The subscripts will be dropped for this subsection with the understanding that the equations will be computed for the particular station-base-frequency pairs for which ϕ_{ik} is available in this time slot.)

Computational parameters

$$\Delta t_m = 10 \text{ seconds}$$

$$C = \cos \theta$$

$$S = \sin \theta$$

2) Phase Rate Update

$$L_3 = \sigma_{\phi\phi}^2 - \sigma_{\phi\dot{\phi}}^2 \Delta t_m + \sigma_{ik}^2$$

NOTE: L_2 and the 2nd term of $\hat{\Delta\phi}(k+1)$ are computed by the L ALPHA Subroutine, page 15.

$$L_2 = \frac{\sigma_{\phi\dot{\phi}}^2 \Delta t_m \left[\sigma_{\phi\dot{\phi}}^2 \Delta t_m + L_3 C \right]}{\left[L_3 + \sigma_{\phi\dot{\phi}}^2 \Delta t_m C \right]^2 + \left[\sigma_{\phi\dot{\phi}}^2 \Delta t_m S \right]^2}$$

(If $L_2 > 2$ then set $L_2 = 2$; computed in the L ALPHA Subroutine)

$$\hat{\Delta\phi}(k+1) = \hat{\Delta\phi}(k) + \frac{1}{\Delta t_m} \tan^{-1} \frac{\sigma_{\phi\dot{\phi}}^2 \Delta t_m S}{L_3 + \sigma_{\phi\dot{\phi}}^2 \Delta t_m C}$$

TEST:

is $|\hat{\Delta\phi}| > 4 \text{ dec's/sec}$

Yes. Then set $\hat{\Delta\phi} = 0$ and continue

No. Then continue

p11/4 to 8

$$\sigma_{\phi\dot{\phi}}^2(k+1) = \sigma_{\phi\dot{\phi}}^2(k) \frac{L_2^2}{(\Delta t_m)^2} \left[\sigma_{\phi\phi}^2(k) + \sigma_{ik}^2 \right] - \frac{2L_2 \sigma_{\phi\dot{\phi}}^2(k)}{\Delta t_m}$$

$$\text{If } \sigma_{\phi\dot{\phi}}^2(k+1) = \frac{1}{2\pi^2} \text{ then set } \sigma_{\phi\dot{\phi}}^2(k+1) = \frac{1}{2\pi^2}$$

p12/1,2

NOTE: L_1 and the 2nd term of the $\hat{\phi}(R+1)$ equation are computed in the L ALPHA subroutine, page 15.

$$L_1 = \frac{\sigma_{\phi\phi}^2 \left[\sigma_{\phi\phi}^2 + \sigma_{ik}^2 C \right]}{(\sigma_{ik}^2 + \sigma_{\phi\phi}^2 C)^2 + (\sigma_{\phi\phi}^2 S)^2}$$

(If $L_1 > 1$ then set $L_1 = 1$)

3) Update of Phase Estimates

p12/3

$$\hat{\phi}(k+1) = \hat{\phi}(k) + \tan^{-1} \frac{\sigma_{\phi\phi}^2 S}{\sigma_{ik}^2 + \sigma_{\phi\phi}^2 C}$$

4) Cross Variance Update

p12/4

$$\sigma_{\phi\dot{\phi}}^2(k+1) = (1-L_1) \left[\sigma_{\phi\dot{\phi}}^2(k) - \frac{L_2}{\Delta t_m} \sigma_{\phi\phi}^2(k) \right] + \frac{L_1 L_2 \sigma_{ik}^2}{\Delta t_m}$$

5) Update of Variance of the Phase-Difference Estimate

p12/§3 to P13/§5

$$\sigma_{\phi\phi}^2(k+1) = (1-L_1)^2 \sigma_{\phi\phi}^2(k) + L_1^2 \sigma_{ik}^2$$

If $(1-L_1)^2 \sigma_{\phi\phi}^2(k+1) > 1 \text{ (cycle)}^2$ then set $\sigma_{\phi\phi}^2(k+1) = 1$

g) Increment n-Counters

p13/§5+1 to p14/§8

Test

Is $\sigma_{\phi\phi}^2 \leq (3. \text{ cec})^2$ and $\sigma_{\phi\dot{\phi}}^2 \leq (0.03 \text{ cec})^2$

Yes: then increment n-counter by +1

No: then reset n-counter to zero

when Measurement Update iterations have been completed and n-counters have been incremented, then exit.

Additional Note: A Tracking Filter Functional Requirement is the integral Lane Count Check (found in paragraph 3.3.10 (c) 4, Volume 1) which requires that periodically the Tracking Filter will compare its phase difference estimate (in cec's) with the phase difference estimate from the propagation prediction routine.

This requirement has been allocated to PROPAGATION PREDICTION. This means that it cannot be represented in the Tracking Filter flow diagram, since the time of occurrence is not precisely known.

3.1.4 Description of Subroutines Used by the Tracking Filter Subprogram

a) L ALPHA (page 15)

This subroutine accepts three arguments (θ , B, and A) and returns ALPHA and L.

$$L = \frac{(A \cos \theta + B) B}{(A + B \cos \theta)^2 + (B \sin \theta)^2}$$

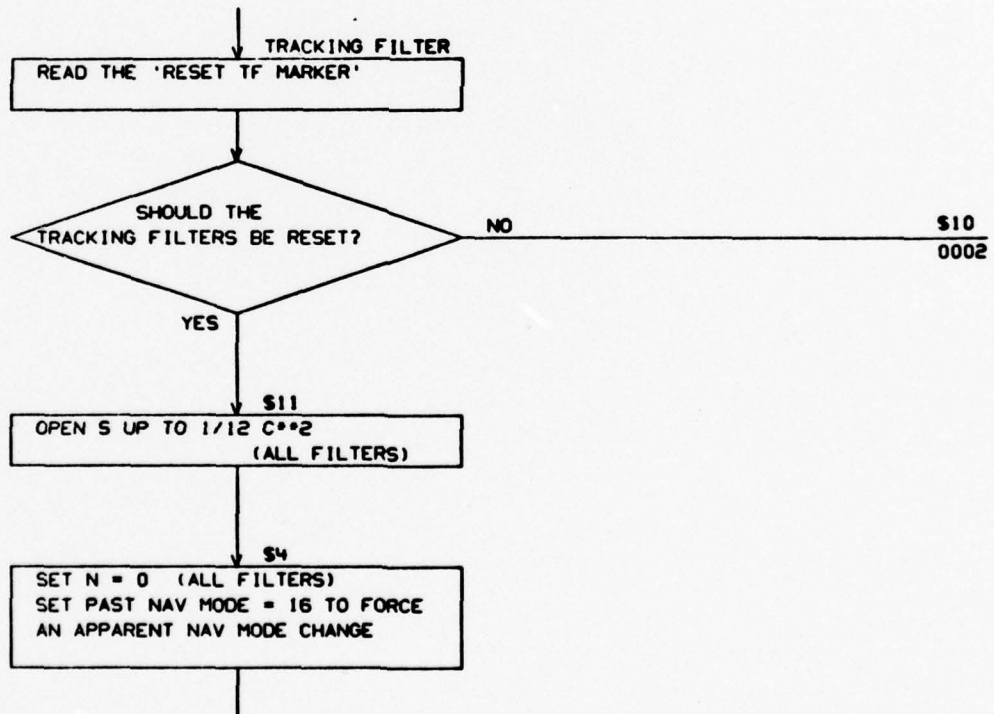
$$\text{ALPHA} = \text{TAN}^{-1} \left(\frac{B \sin \theta}{A + B \cos \theta} \right)$$

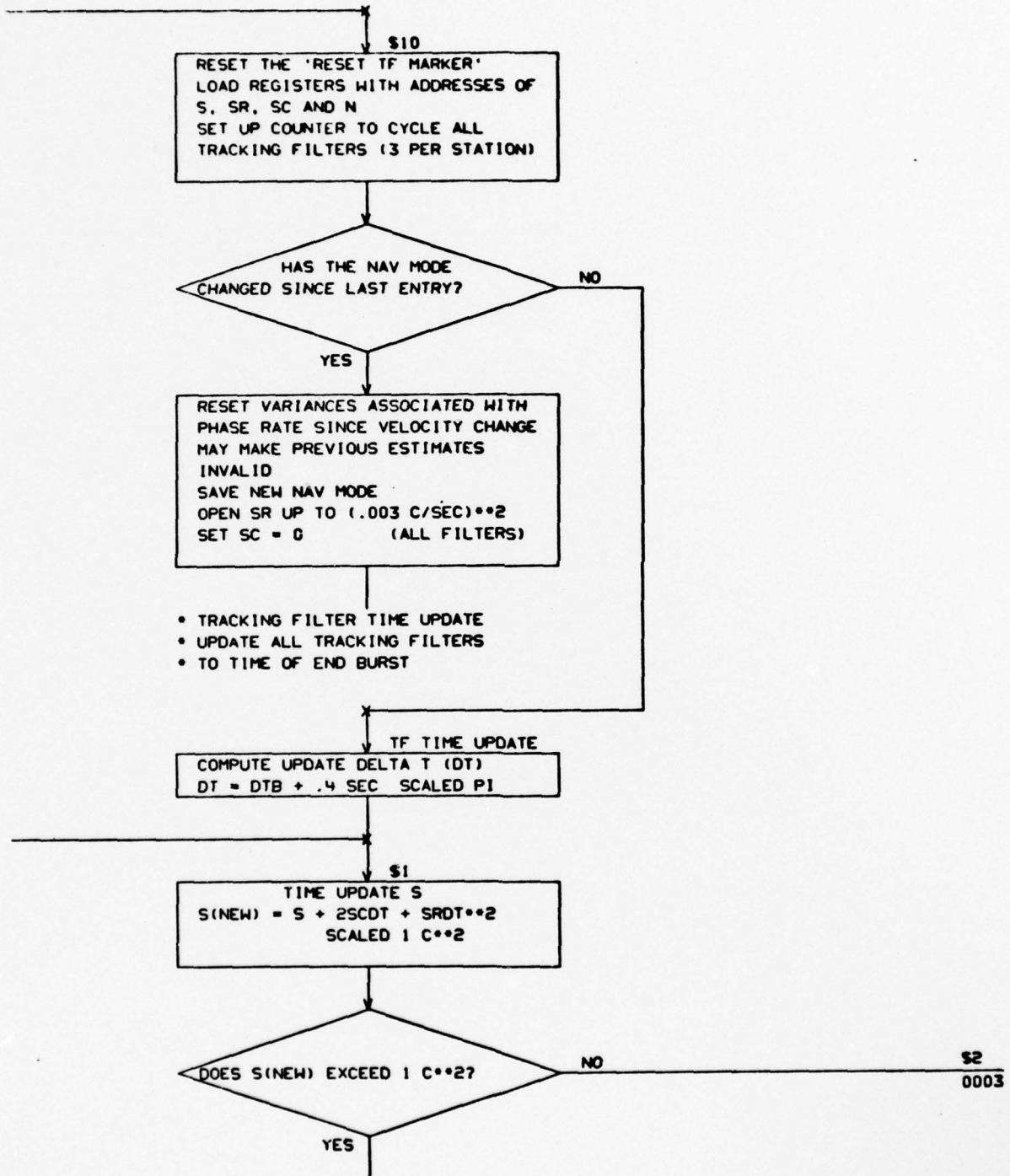
3.2 FLOW CHARTS

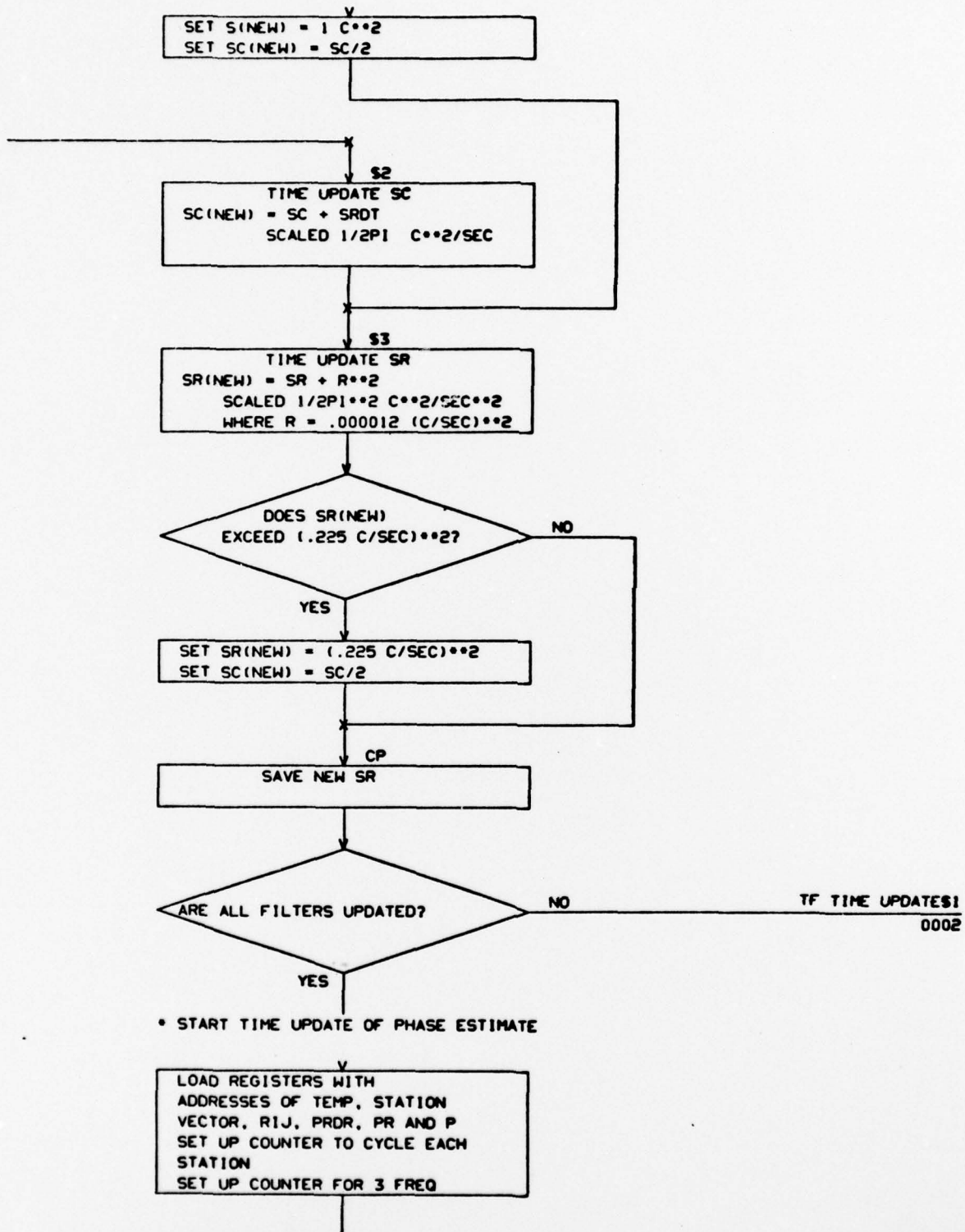
The Tracking Filter Subprogram flow charts are presented in the following pages.

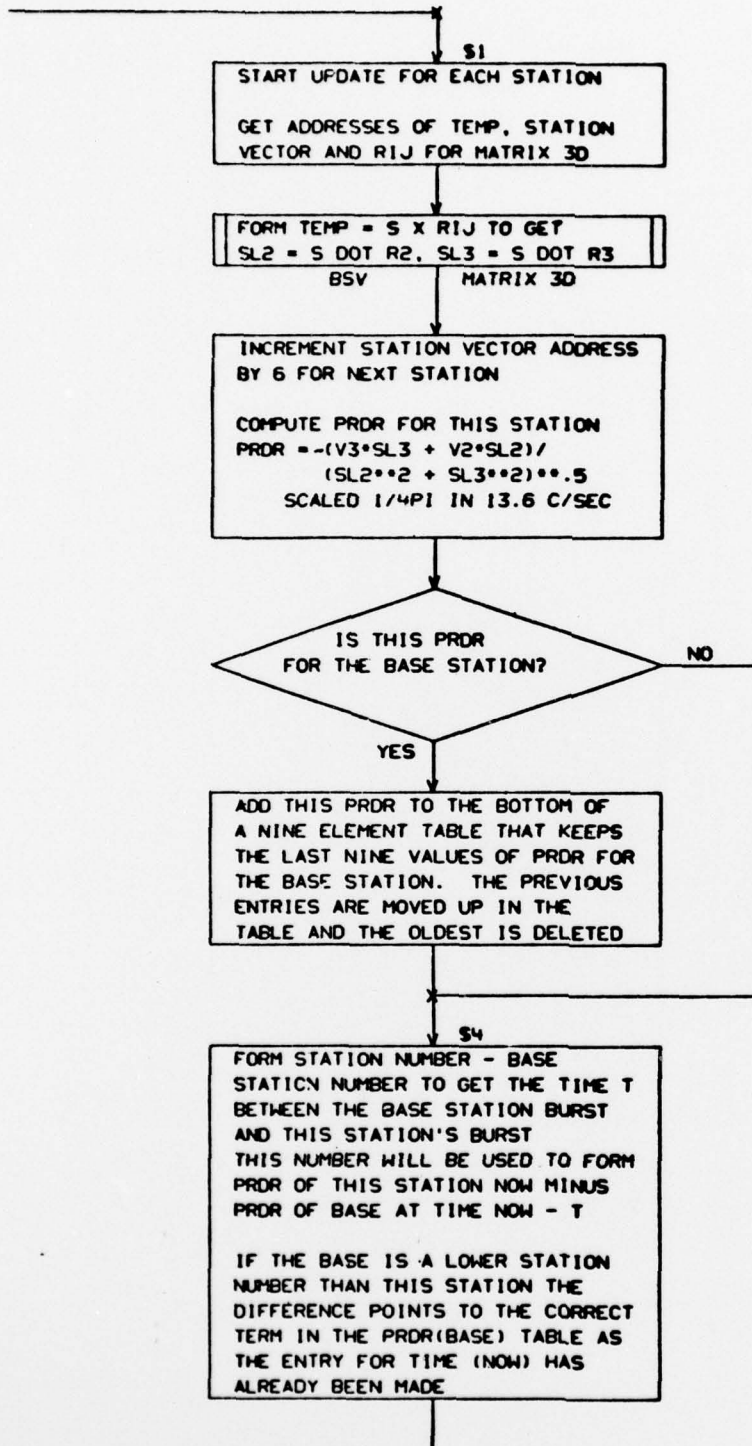
TRACKING FILTER

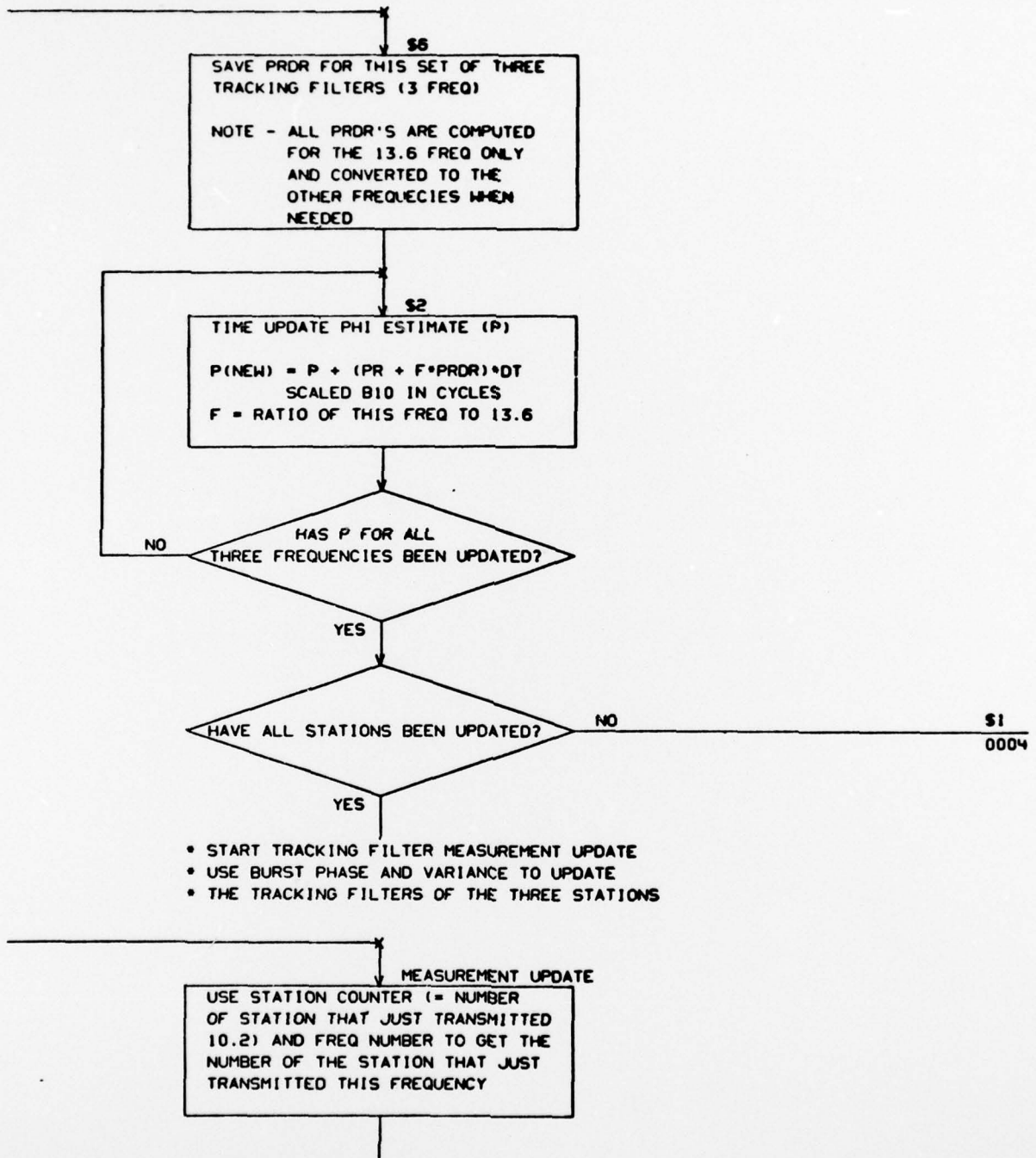
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-
- THIS PROGRAM IS EXECUTED AT THE END OF EVERY STATION BURST.
- IT SMOOTHES THE COMPUTED PHASE AND PROVIDES OUTPUTS TO KALMAN.
-
- FOR NOTATIONAL PURPOSES THE SYMBOLS LISTED BELOW WILL BE USED
-
- PB = BURST PHASE MEASUREMENT
- SB = BURST PHASE MEASUREMENT VARIANCE
- P = TRACKING FILTER PHASE ESTIMATE
- PR = TRACKING FILTER PHASE RATE ESTIMATE
- PRDR = PHASE RATE DUE TO CRAFT MOTION TOWARDS THE STATION
- DTB = DELTA T BURST
- DT = TIME BETWEEN TRACKING FILTER TIME UPDATES
- S = TRACKING FILTER PHASE ESTIMATE VARIANCE
- SR = TRACKING FILTER PHASE RATE ESTIMATE VARIANCE
- SC = CROSS CORRELATION OF PHASE AND PHASE RATE VARIANCE
- C = CYCLE
- N = TRACKING FILTER N COUNTERS
- DTM = TIME BETWEEN TRACKING FILTER MEASUREMENTS (10 SECONDS)
-

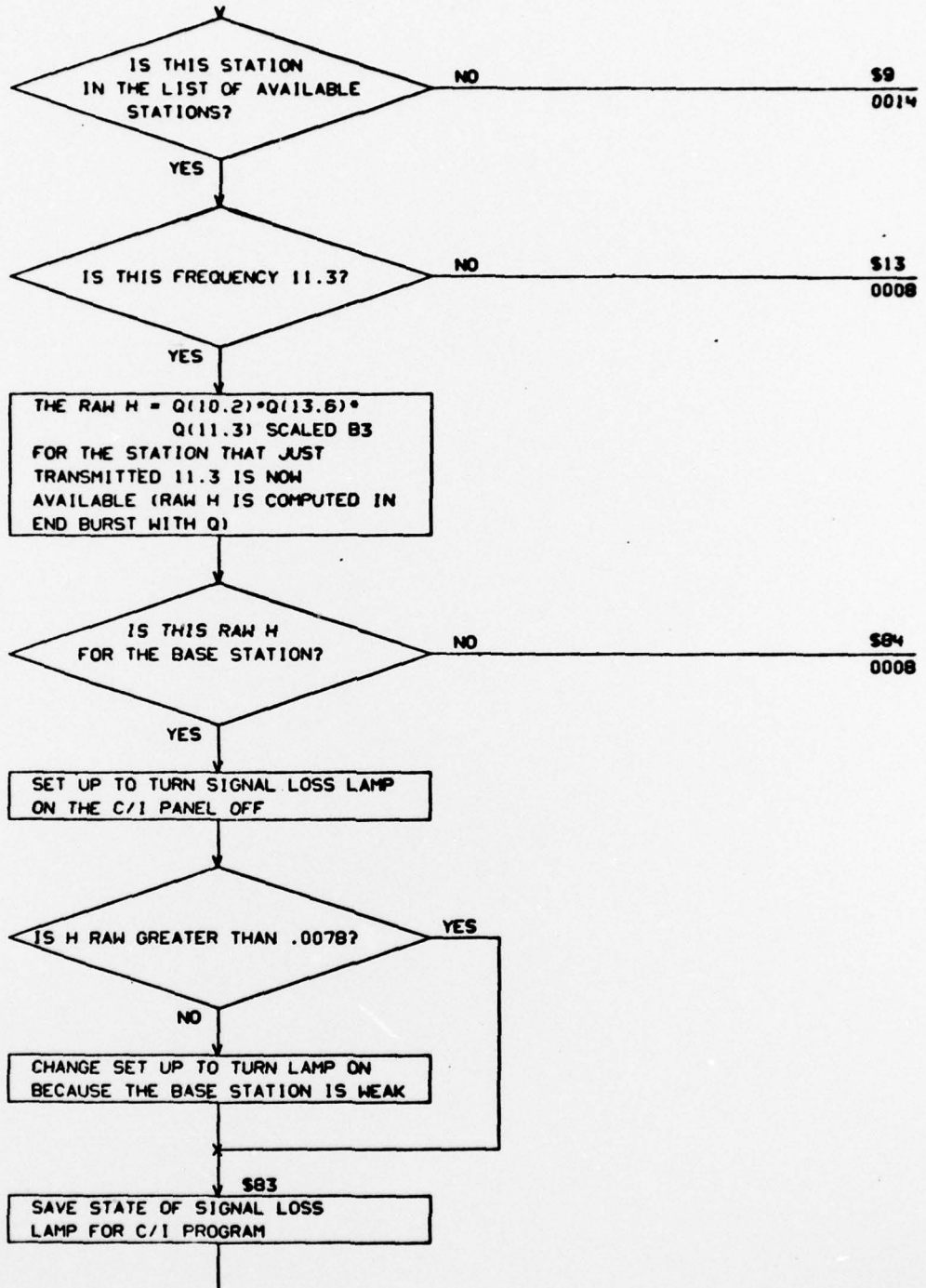


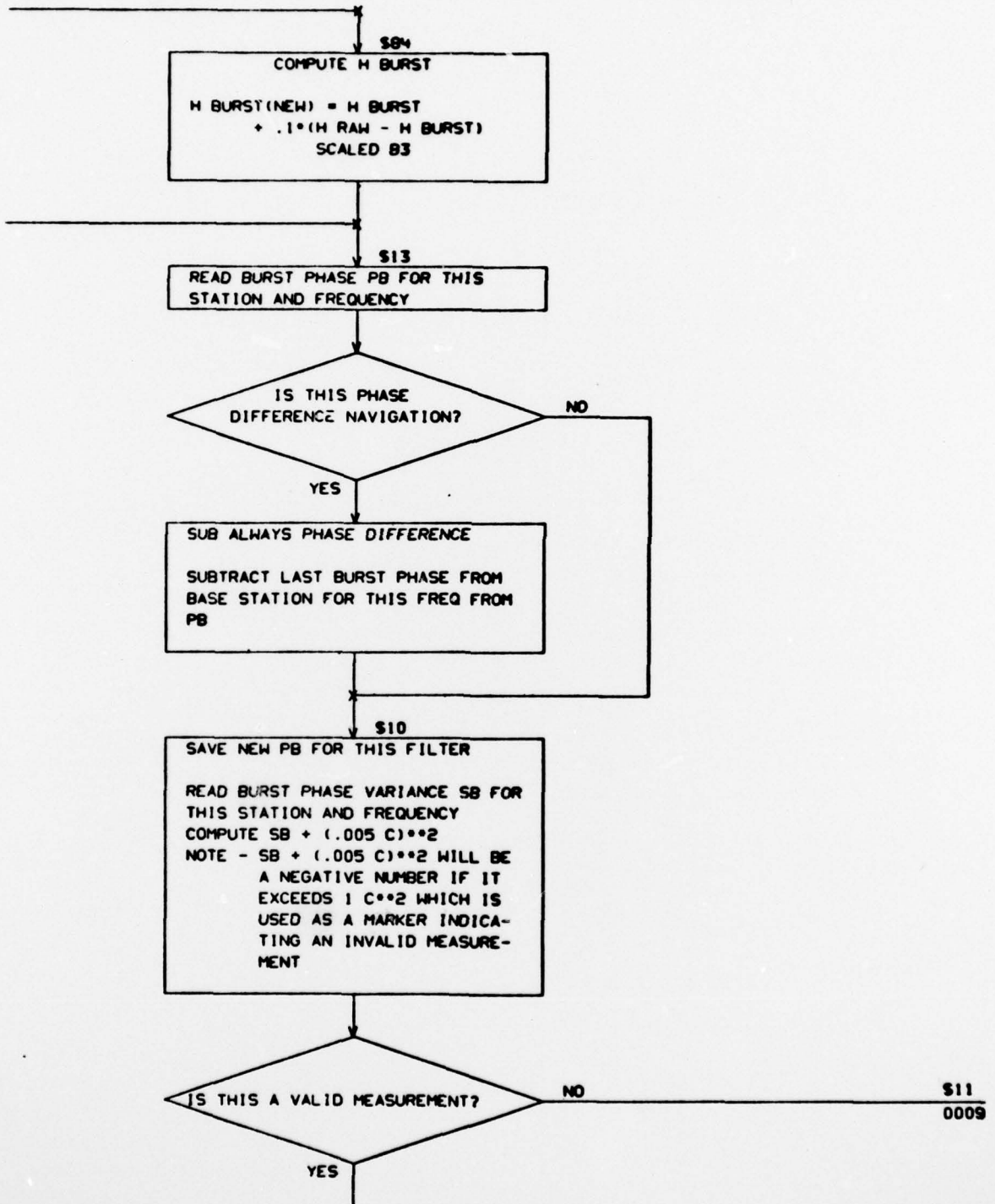


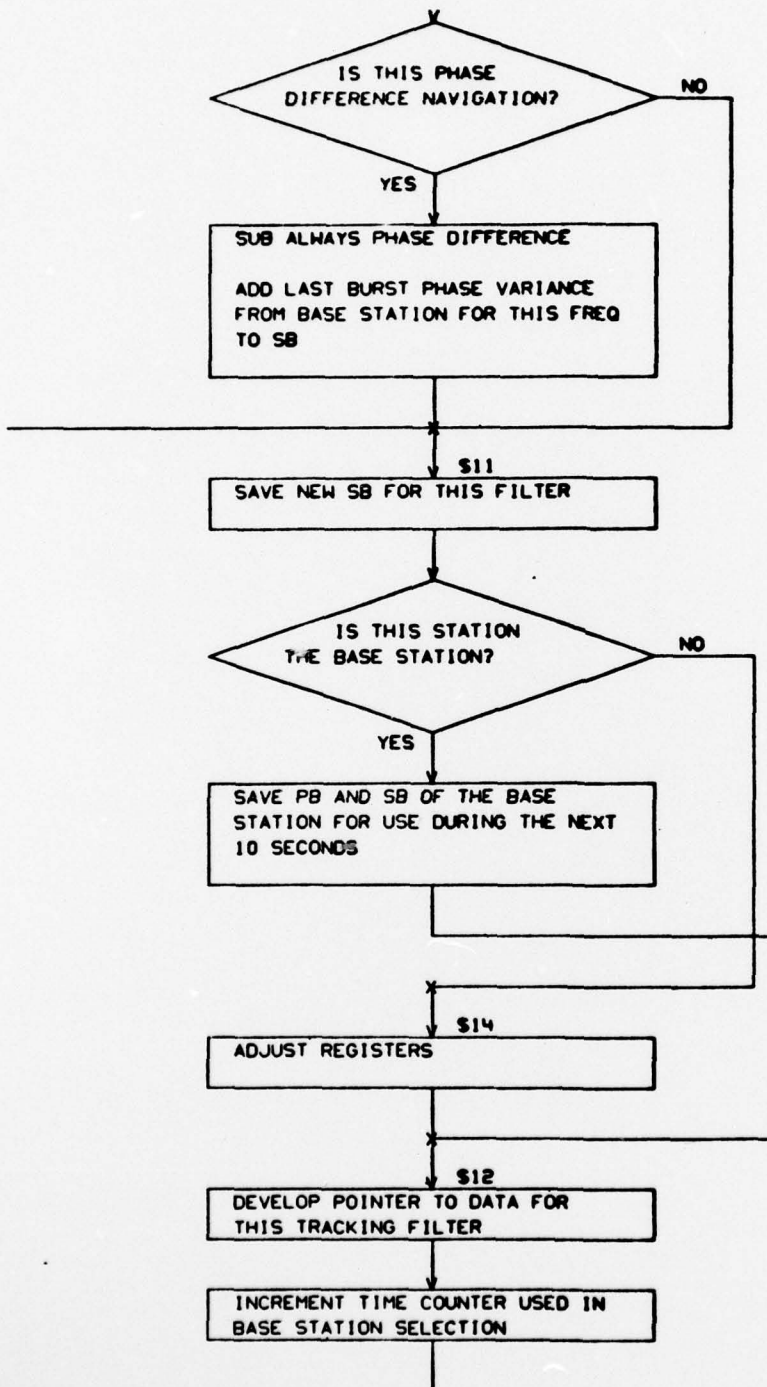


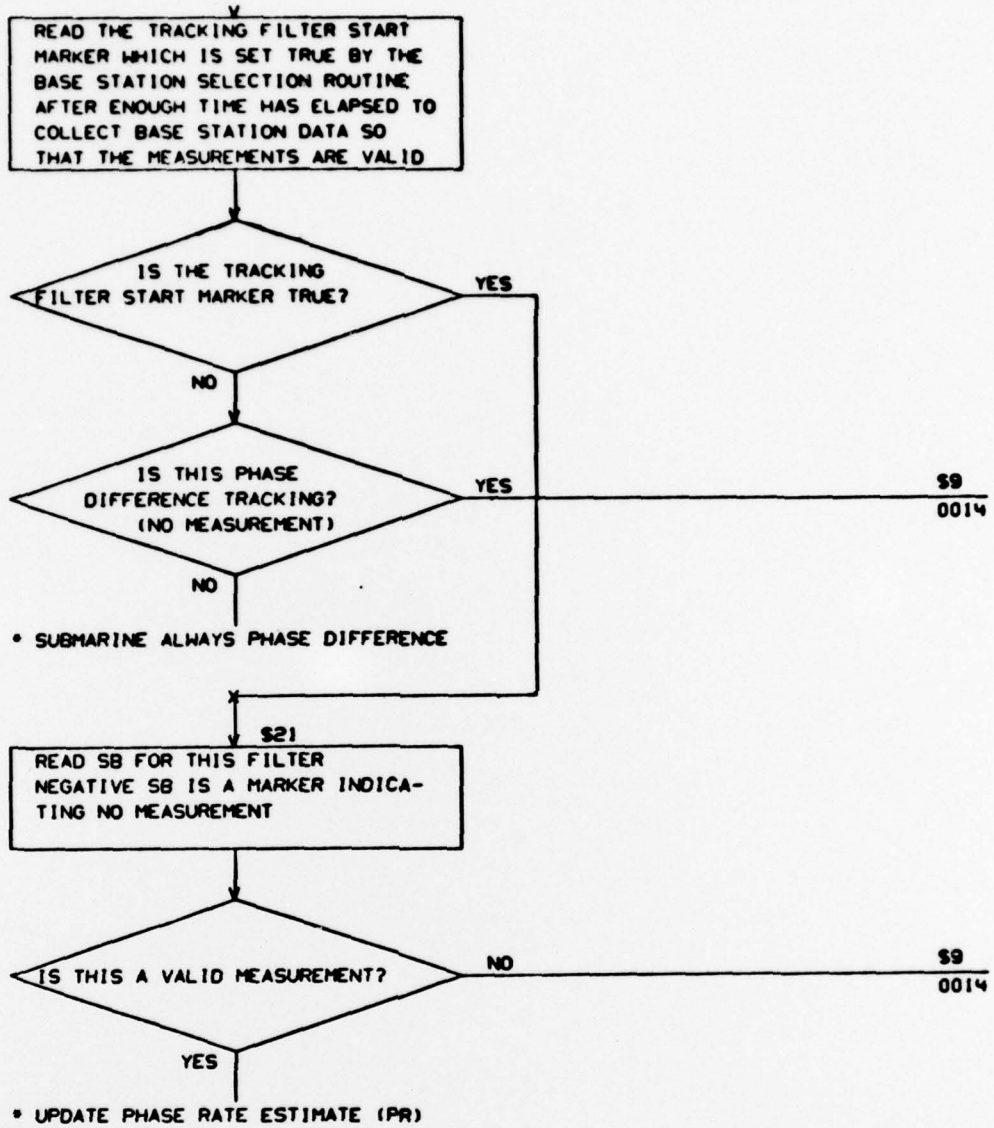


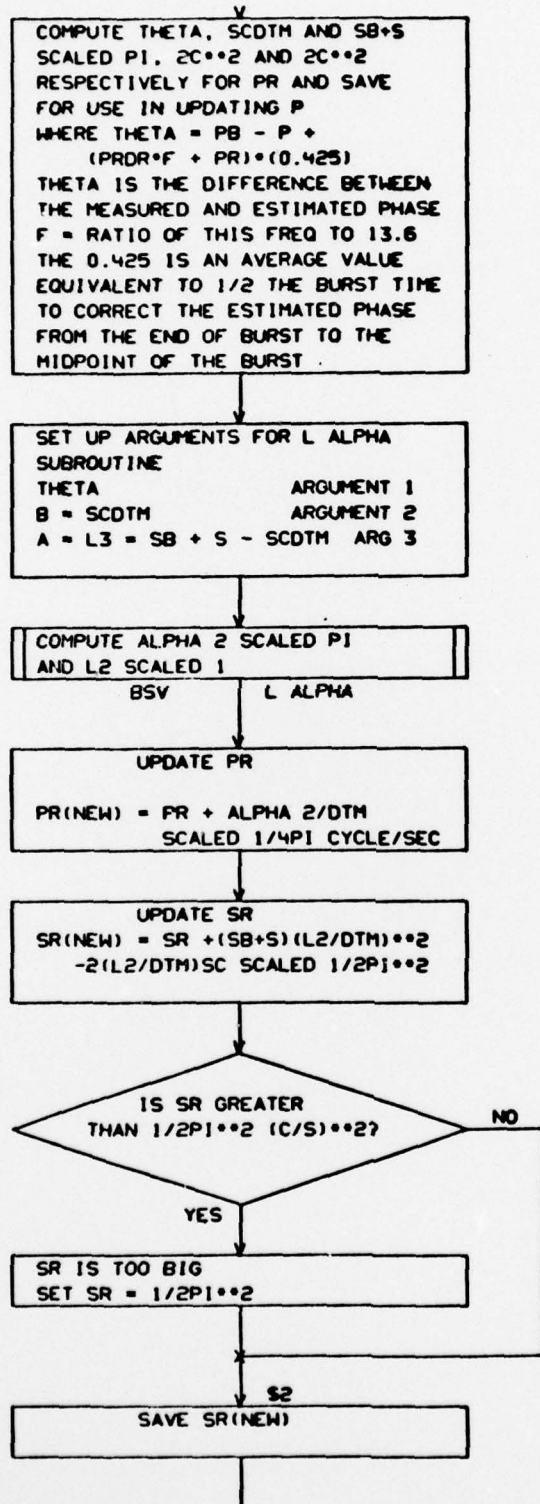


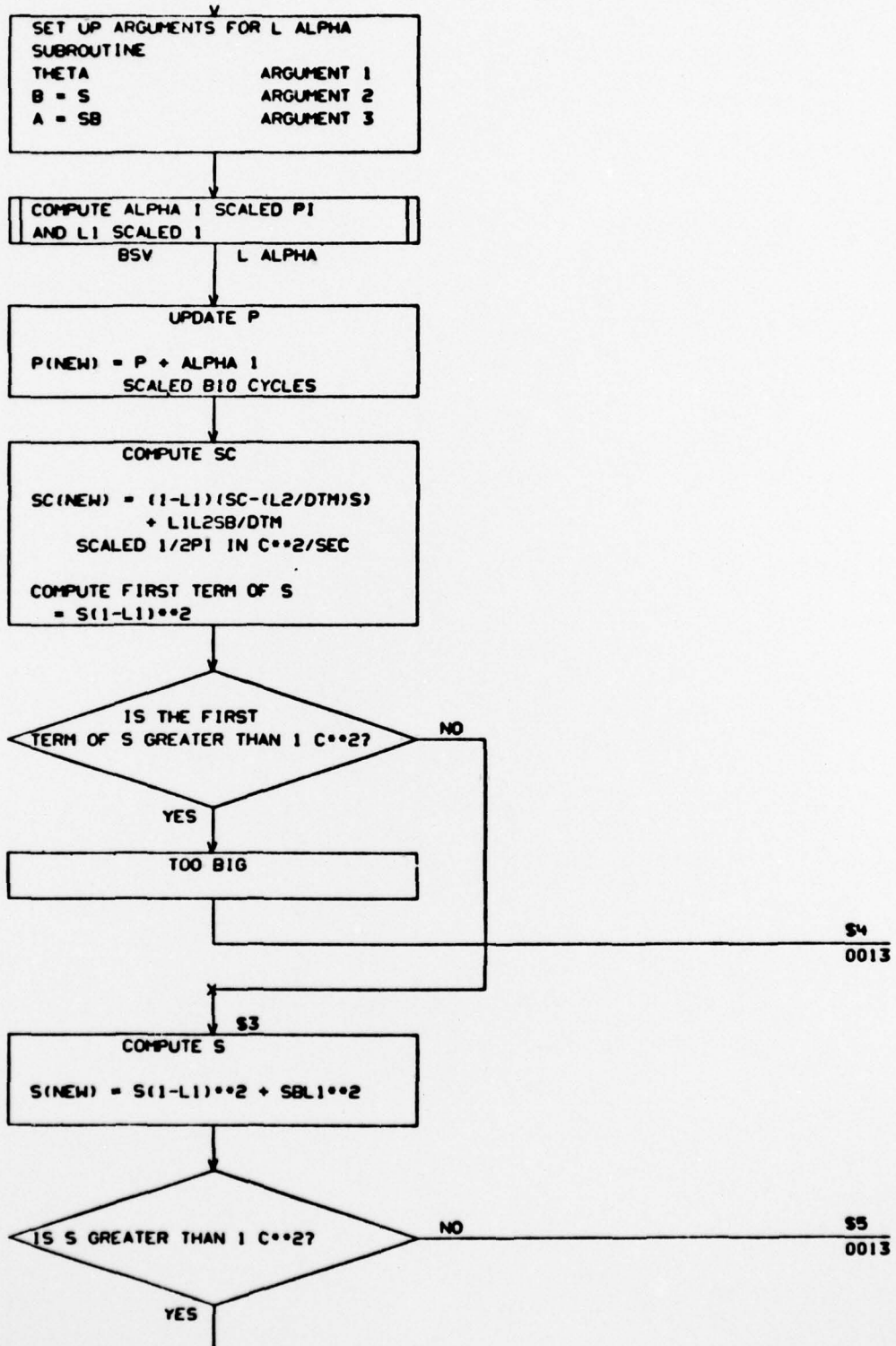


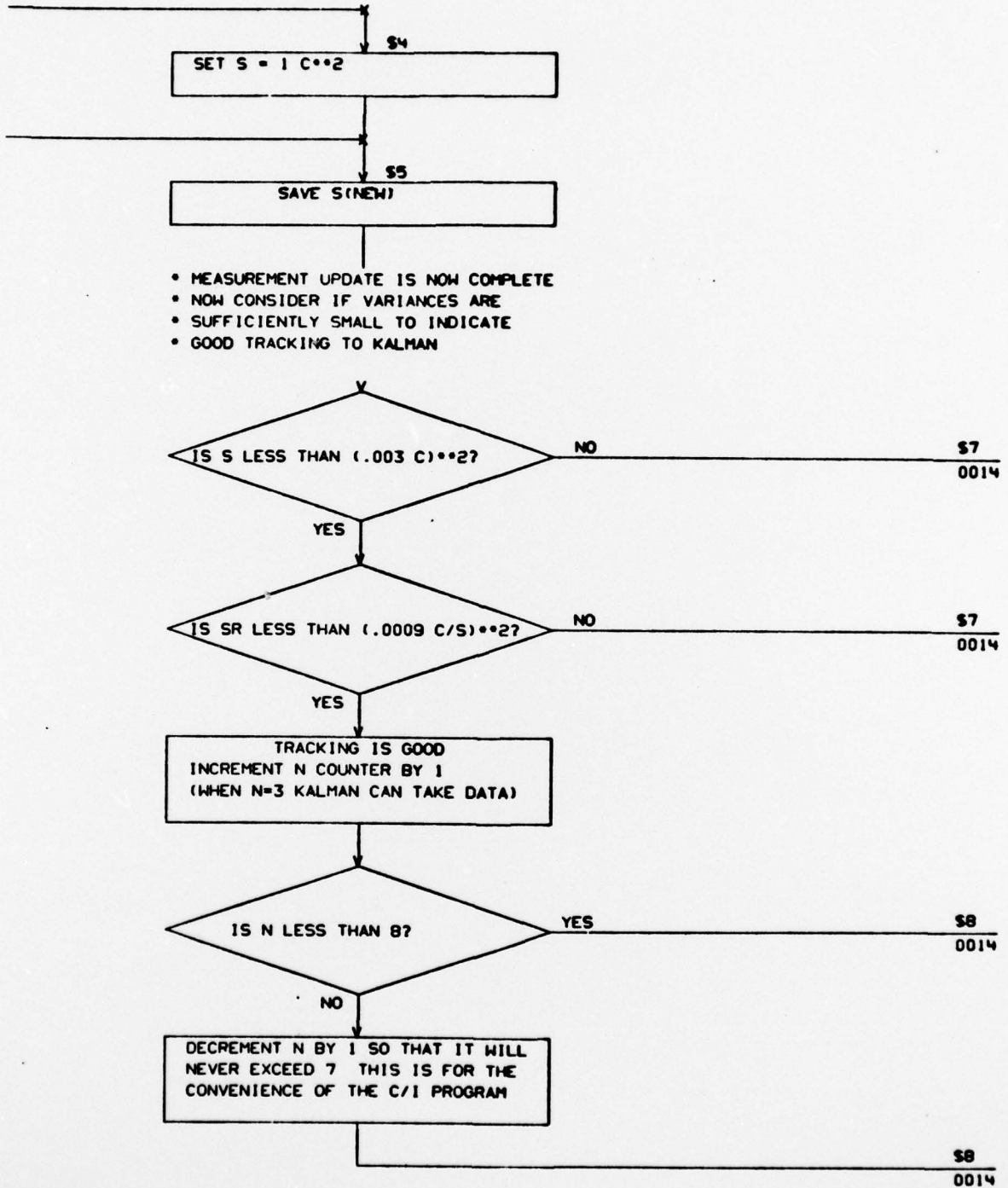


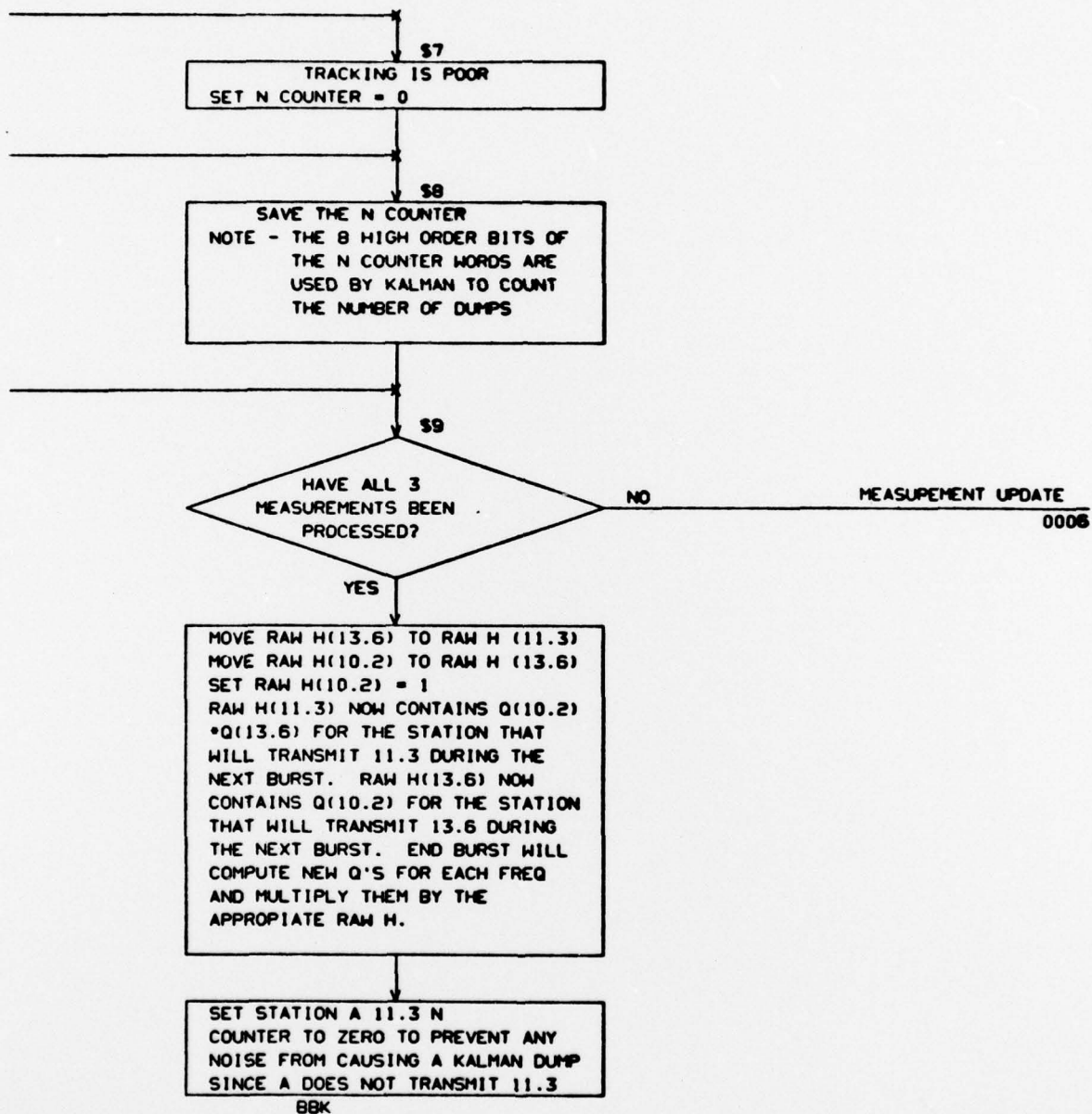




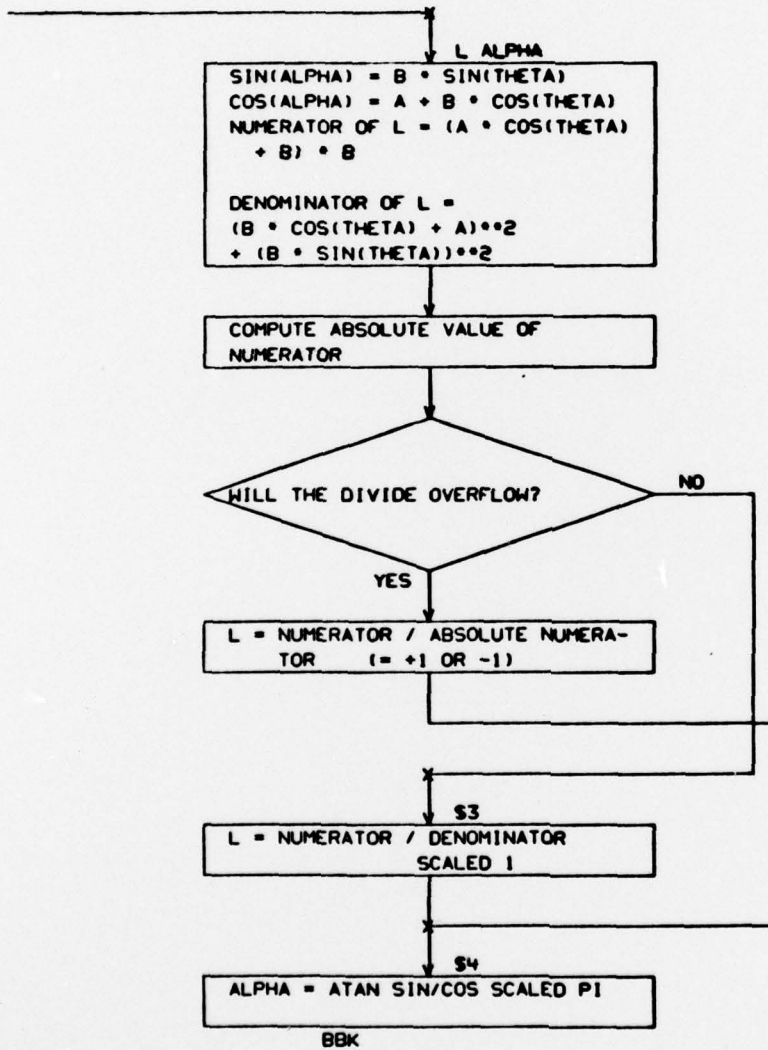








-
- L ALPHA SUBROUTINE
- THIS ROUTINE WILL ACCEPT 3 ARGUMENTS (THETA, B AND A)
- AND RETURN ALPHA AND L
-



3.3 COMPUTER SUBPROGRAM ENVIRONMENT

3.3.1 Tracking Filter Tables

- a) Frequency Ratio Table. The Frequency Ratio Table is used to convert PHI DOT DR from 13.6 cycles per second to the appropriate frequency.

The table has three entries that consist of the ratio of the selected frequency to the 13.6 frequency. The table has the usual order of 10.2, 13.6 and 11-1/3. The official label of this table is TF LAMBDA CONSTANT TABLE.

- b) Station Location. This table contains the location of all existing OMEGA transmitting stations. Each location is specified as a three-element geocentric position vector. The first entry is for station A. The table is defined in detail in the listing. The official name of this table is STATION VECTOR TABLE.

3.3.2 Temporary Storage

The Tracking Filter program requires six words of temporary storage in addition to that storage used in the R15 pushdown stack.

3.3.3 Input/Output Formats

Not applicable.

3.3.4 Required System Library Subroutines

Subroutine	Functional Description (Section 3.1.3)	Flow Diagram	Subprogram Design Document (by Volume)
ATAN	f-2	L ALPHA Sub	XII Common Subroutines
MATRIX 3D	c-1	P4/\$1+1	XII Common Subroutines
SIN-COS	f-1	L ALPHA (Page 15)	XII Common Subroutines
SQRT	c-2	p4/\$1+4	XII Common Subroutines