VISSR ATMOSPHERIC SOUNDER

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Work completed during January is summarized in the two attached reports: "Extended Simulation of Registration Errors and Correction Procedures" prepared by R. DeDecker, and "Effects of Calibration Procedures on Variance of Radiance for VISSR", prepared by Appa Madiwale. The former shows relatively encouraging results suggesting that registration errors in array fabrication can be adequately corrected if they are known. The latter shows that the signal variance is a relatively weak function of the precise time locations of D.C. restore and shutter insertion relative to the earth and that within rather broad limits mechanical and other such conveniences can safely be accommodated.

Work during February will concentrate on further analysis of registration errors, calibration and processing techniques, and operational procedures.

EXTENDED SIMULATION OF REGISTRATION
ERRORS AND CORRECTION PROCEDURES

prepared by

R. DeDecker

11 February 1974

In order to study the effects of north-south misalignment between detector arrays, a computer simulation technique was developed. A description of the simulation algorithm, along with preliminary results, is given in the appendix of the December progress report (#4) on NAS5-21965. To further investigate the effects of various types and amounts of cloud cover, the same simulation technique was applied to four additional images, a Gemini image over Mexico, and Apollo images over Texas, Louisianna, and western Africa. The gridded images were also evaluated for amounts of cloud cover for each of the cloud types. Table 1 provides a summary of these cloud statistics over the new grids along with the Canary Islands grid.

In addition to a .4mr x .4mr detector misalignment simulation, the grids were used in a simulation of a .8mr x .8mr detector array. Table 2 provides a summary of RMS errors for each of the two detector arrays and misalignment factors.

To normalize the effects of grid sizes (Apollo images are at the same resolution as Gemini but cover only 1/4 of the area) and various cloud type temperatures so as to provide a meaningful comparison of results, the following formula was applied to each grid for the .015 mr misalignment factor.

$$\overline{I_{CD}} = \frac{\sum_{i=1}^{b} N_i I_i}{\sum_{i=1}^{b} N_i}$$

where:

$\overline{I_{CD}}$ = mean cloud radiance for the grid

N_i = fractional cloud cover of each cloud type

I_i = radiance of each cloud type

i = ith cloud type

Table 3 summarizes these results along with the clear column radiance (I_{CL}) for each grid and the difference between I_{CL} and $\overline{I_{CD}}$. Figure 1 is a plot of RMS errors vs. $I_{CL} - \overline{I_{CD}}$ for each of the two detector array sizes with a misalignment of .015mr.

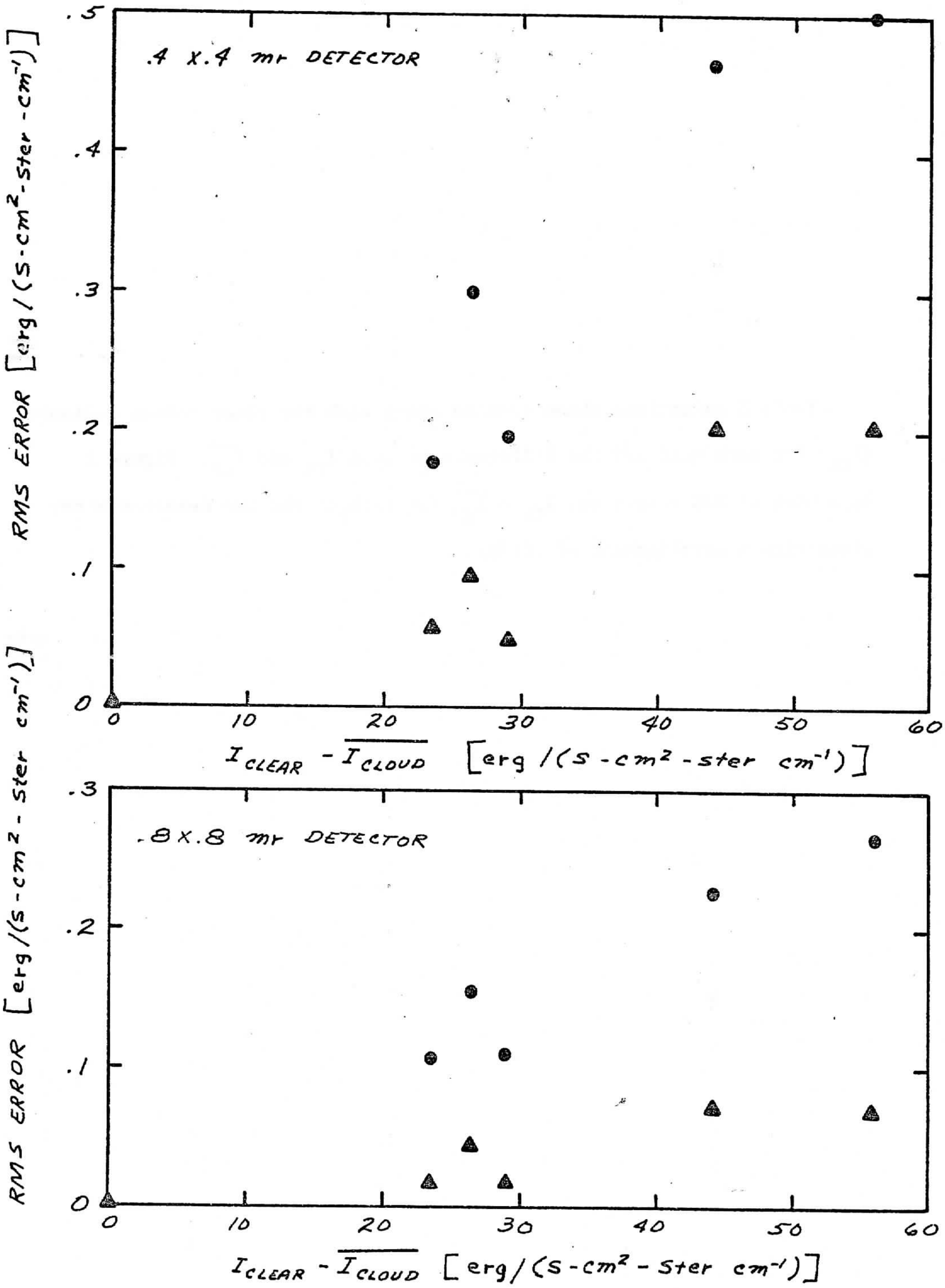

FIGURE 1 SIMULATION RMS ERRORS FOR CLOUD NORMALIZED IMAGE GRIDS AT A MISALIGNMENT OF 15 μr

● UNCORRECTED ▲ CORRECTED

Table 1. Cloud Grid Statistics for Each Cloud Type and Grid Used in Misalignment Test Simulations

Image Grid	Cloud Emissivity	Cloud Transmissivity	Cloud Reflectivity	Cloud Height (mb)	% of Cloud Contaminated FOV's as a Function of FOV Size: Image Resolution	.1mr	.2mr	.4mr	.8mr
Canary I.	- - - A L L	C L O U D T	Y P E S - - - -	- - - - - -	27.0	46.9	63.6	82.9	97.2
Canary I.	.8	0	.2	800	12.9	25.6	46.2	74.6	95.8
Canary I.	.85	0	.15	350	14.1	21.3	31.9	47.8	68.1
Mexico	- - - A L L	C L O U D T	Y P E S - - - -	- - - - - -	17.8	39.0	51.6	66.4	80.6
Mexico	1.0	0	0	700	7.1	19.4	30.7	45.9	62.5
Mexico	1.0	0	0	400	8.7	14.8	22.1	33.8	53.5
Mexico	0.3	0.5	0.2	400	2.1	4.9	7.7	13.1	23.6
Texas	- - - A L L	C L O U D T	Y P E S - - - -	- - - - - -	33.0	58.3	70.6	82.6	100.0
Texas	1.0	0	0	700	15.4	29.5	37.1	49.3	63.9
Texas	1.0	0	0	550	6.6	14.4	21.9	32.6	63.9
Texas	1.0	0	0	300	11.0	14.4	15.7	14.6	19.4
Louisianna	- - - A L L	C L O U D T	Y P E S - - - -	- - - - - -	41.0	68.3	78.7	91.0	100.0
Louisianna	1.0	0	0	700	17.2	30.5	38.0	56.3	75.0
Louisianna	.7	.3	0	700	2.1	4.8	9.1	19.4	36.1
Louisianna	1.0	0	0	550	3.3	4.8	7.0	11.8	22.2
Louisianna	.7	.3	0	550	3.5	8.6	14.2	27.8	50.0
Louisianna	.4	.6	0	550	1.1	2.6	4.6	11.8	16.7
Louisianna	1.0	0	0	300	9.2	10.2	11.4	10.4	13.9
Louisianna	0.7	0.3	0	300	3.0	4.0	6.4	9.0	13.9
Louisianna	0.4	0.6	0	300	1.6	2.7	4.8	10.4	16.7
Africa	- - - A L L	C L O U D T	Y P E S - - - -	- - - - - -	23.9	45.6	55.8	63.2	77.8
Africa	1.0	0	0	950	5.8	13.9	22.2	36.8	61.1
Africa	1.0	0	0	800	8.1	15.5	22.6	31.9	50.0
Africa	1.0	0	0	650	2.1	5.0	7.2	13.2	25.0
Africa	1.0	0	0	550	6.8	11.2	15.2	22.2	36.1

Table 2. Simulation Results for .4 x .4mr and .8 x .8mr Detector Arrays for Each Image Grid at Various Misalignment Factors

Image Grid	Misalignment (mr)	RMS Error [erg/(s-cm^2-ster-cm^{-1})] .4 x .4mr		.8 x .8mr	
		Uncorrected	Corrected	Uncorrected	Corrected
Canary I.	.005	.166	.068	.089	.023
Canary I.	.010	.333	.136	.177	.047
Canary I.	.015	.499	.203	.266	.070
Canary I.	.025	.832	.339	.443	.117
Canary I.	.050	1.663	.678	.887	.234
Mexico	.005	.154	.067	.076	.024
Mexico	.010	.308	.134	.152	.049
Mexico	.015	.462	.202	.227	.073
Mexico	.025	.770	.336	.379	.122
Mexico	.050	1.540	.672	.758	.244
Texas	.005	.064	.017	.037	.006
Texas	.010	.128	.034	.074	.012
Texas	.015	.192	.050	.110	.018
Texas	.025	.321	.084	.184	.029
Texas	.050	.641	.168	.368	.059
Louisianna	.005	.058	.019	.036	.006
Louisianna	.010	.115	.038	.071	.012
Louisianna	.015	.173	.058	.107	.018
Louisianna	.025	.288	.096	.179	.030
Louisianna	.050	.576	.192	.357	.061
Africa	.005	.099	.031	.052	.015
Africa	.010	.198	.062	.103	.030
Africa	.015	.298	.093	.155	.045
Africa	.025	.496	.155	.258	.074
Africa	.050	.992	.310	.515	.149

Table 3. Simulation RMS Error Results for Normalized Image Grids at a Misalignment of .015 mr -- Radiances are in erg/(s-cm^2-ster-cm^{-1})

Image Grid	$\overline{I_{CD}}$	I_{CL}	$I_{CL} - \overline{I_{CD}}$	RMS Error .4 x .4mr Uncorrected	RMS Error .4 x .4mr Corrected	RMS Error .8 x .8mr Uncorrected	RMS Error .8 x .8mr Corrected
Canary I.	36.52	92.49	55.96	.499	.203	.266	.070
Mexico	71.04	115.08	44.03	.462	.202	.227	.073
Texas	47.63	76.55	28.92	.192	.050	.110	.018
Louisianna	53.10	76.55	23.44	.173	.058	.107	.018
Africa	62.30	88.61	26.30	.298	.093	.155	.045

EFFECTS OF CALIBRATION PROCEDURES ON VARIANCE OF RADIANCE FOR VISSR

prepared by

Appa Madiwale

8 February 1974

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EFFECTS OF CALIBRATION PROCEDURES ON VARIANCE OF

DETECTOR SIGNALS FOR VISSR

Based on a model of type $\sigma^2(a + b\ln \tau)$ for covariance of noise radiance, a formula is derived for variance of noise radiance in Appendix I. The calibration procedure considered is:

1) Space scan-time interval Δ_1.
2) Time interval between end of space scan and start of earth scan δ_1.
3) Earth scan time interval Δ_2.
4) Time interval between end of earth scan and start of shutter scan δ_2.
5) Shutter scan Δ_3.

The purpose of analysis is to select optimally the timings so that we get minimum variance of noise radiance. This derivation is based on the covariance model prior to D·C·Restore. Effects of D·C·Restore are taken care of by signal averaging during the time interval Δ_1.

In Appendix II a program was written to compute variance of noise radiance varying one variable at a time and holding others at their nominal values. Two sets of nominal values and model parameter values were used.

Based on those results and graphs, there seems to be no significant change in variance even if parameter values are varied on a substantially large range. Generally decreasing δ_1 and δ_2 will result in lower variance, and there exist a combination of Δ_1 and Δ_3 for minimum variance. But it should be noted that this minimum is not significantly different than other values.

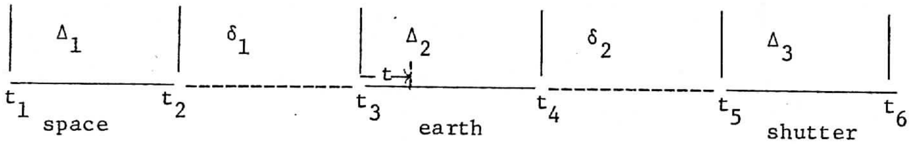
In Appendix III, the problem of minimisation was formulated in such a way that standard Gradient Projection Method subroutine available on UNIVAC

1110 could be used. The results of this program reinforce the observation made on the basis of results in Appendix II.

We conclude that there is not significant change in variance of noise radiance by varying the time intervals involved in calibration procedure. If there was to be a high correlation (i.e., a and b as covariance model to be large), it would have reduced variance. So mechanical conveniences should govern the selection of those timings. The maximum changes noticed while minimizing are less than 5%. More critical variables are DELTA1 and DELTA3 which are both .027 sec at minimum variance. $C(\tau au)$ = .02278 - .0266 $\log(\tau)$ for FC = 750 Hz, FMAX=26000 Hz, Fmin = .026 Hz.

It can be seen that for this case, the behavior of variance of noise radiance is similar to case of FMAX = 17450 Hz which is extensively investigated in this report. The ratio $Var/\alpha^2\sigma^2$ will be increased due to lower covariance but the pattern for minimization will be the same and hence the same conclusions hold true for this case too.

APPENDIX I



$$I_E(t) = \alpha[X_E(t) - X_4] + I_4$$

where $\alpha = \dfrac{I_{300} - I_4}{X_{300} - X_4}$

$$\tilde{I}_E(t) = \tilde{\alpha}[\tilde{X}_E(t) - \tilde{X}_4] + I_4$$

where $\tilde{\alpha} = \dfrac{I_{300} - I_4}{\tilde{X}_{300} - \tilde{X}_4}$

$$\tilde{I}_E(t) - I_E(t) = \frac{I_{300} - I_4}{\tilde{X}_{300} - \tilde{X}_4} [\tilde{X}_E(t) - \tilde{X}_4] + I_4$$

$$- \frac{I_{300} - I_4}{X_{300} - X_4} [X_E(t) - X_4] - I_4$$

$$= \frac{I_{300} - I_4}{X_{300} - X_4 + \bar{e}_{300} - \bar{e}_4} [X_E(t) - X_4 + e_t - \bar{e}_4]$$

$$- \frac{I_{300} - I_4}{X_{300} - X_4} [X_E(t) - X_4]$$

$$\tilde{I}_E(t) - I_E(t) = \frac{I_{300} - I_4}{X_{300} - X_4} \cdot$$

$$\cdot \left\{ \frac{[X_E(t)-X_4+e_t-e_4](X_{300}-X_4) - [X_E(t)-X_4](X_{300}-X_4+\bar{e}_{300}-\bar{e}_4)}{X_{300} - X_4 + \bar{e}_{300} - \bar{e}_4} \right\}$$

$$= \alpha \frac{(X_{300}-X_4)(e_t-e_4) - [X_E(t)-X_4](\bar{e}_{300}-\bar{e}_4)}{X_{300} - X_4 + \bar{e}_{300} - \bar{e}_4}$$

$$= \alpha \frac{e_t - \bar{e}_4 - \beta\bar{e}_{300} + \beta\bar{e}_4}{1 + \frac{\bar{e}_{300} - \bar{e}_4}{X_{300} - X_4}}$$

where $\beta = \frac{X_E(t) - X_4}{X_{300} - X_4}$

$$\frac{\bar{e}_{300} - \bar{e}_4}{X_{300} - X_4} <<< 1$$

$$\therefore \quad \tilde{I}_E(t) - I_E(t) = \alpha[e(t) - (1-\beta)\bar{e}_4 - \beta\bar{e}_{300}]$$

$$\therefore \quad E\{\tilde{I}_E(t) - I_E(t)\}^2 = \alpha^2\{e(t) - (1-\beta)\bar{e}_4 - \beta\bar{e}_{300}\}^2$$

$$= \alpha^2\{V_t + (1-\beta)^2 V_1 + \beta^2 V_2 - 2(1-\beta)V_{1t} + 2\beta(1-\beta)V_{12} - 2\beta V_{2t}\}$$

where

$$V_t = E\{e_t^2\} = \sigma^2$$

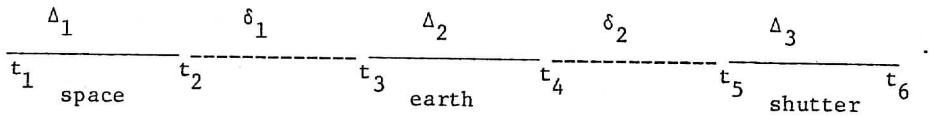
$$V_1 = E\{\bar{e}_4^2\} = \frac{1}{(t_2-t_1)^2} \int_{t_1}^{t_2} dt \int_{t_1}^{t_2} \sigma^2 c(t-t')\,dt'$$

$$V_2 = E\{\bar{e}_{300}^2\} = \frac{1}{(t_6-t_5)^2} \int_{t_5}^{t_6} dt \int_{t_5}^{t_6} \sigma^2 c(t-t')\,dt'$$

$$V_{1t} = E\{e_t\bar{e}_4\} = \frac{1}{t_2-t_1} \int_{t_1}^{t_2} \sigma^2 c(t-t')\,dt'$$

$$V_{2t} = E\{e_t\bar{e}_{300}\} = \frac{1}{t_6-t_5} \int_{t_5}^{t_6} \sigma^2 c(t-t')\,dt'$$

$$V_{12} = E\{\bar{e}_4\bar{e}_{300}\} = \frac{1}{t_2-t_1} \int_{t_1}^{t_2} dt \; \frac{1}{t_6-t_5} \int_{t_5}^{t_6} \sigma^2 c(t-t')\,dt'$$



$$V_1 = \frac{\sigma^2}{\Delta_1^2} \int_{t_1}^{t_2} dt \int_{t_1}^{t_2} c(t-t')\,dt'$$

$$= \frac{2\sigma^2}{\Delta_1^2} \int_0^{\Delta_1} [\Delta_1 - \tau]\, c(\tau)\, d\tau$$

$$= \frac{2\sigma^2}{\Delta_1^2} \int_0^{\Delta_1} [\Delta_1 - \tau][a + b\ln \tau]\, d\tau$$

$$= \sigma^2 (a + b\ln \Delta_1 - \frac{3}{2} b) \qquad (10)$$

Similarly,

$$V_2 = \frac{\sigma^2}{\Delta_3^2} \int_{t_5}^{t_6} dt \int_{t_5}^{t_6} c(t-t')\,dt'$$

$$= \sigma^2 (a + b\ln \Delta_3 - \frac{3}{2} b) \qquad (11)$$

$$V_{1t} = \frac{\sigma^2}{\Delta_1} \int_0^{\Delta_1} c(t + \delta_1 + \Delta_1 - t')\,dt'$$

$$= \frac{\sigma^2}{\Delta_1} \int_0^{\Delta_1} [a + b\ln(t + \delta_1 + \Delta_1 - t')]\,dt'$$

$$= \sigma^2 \left\{ a + \frac{b}{\Delta_1} [(t+\delta_1+\Delta_1)\ln(t+\delta_1+\Delta_1) - (t+\delta_1)\ln(t+\delta_1) - \Delta_1] \right\} \qquad (12)$$

Similarly,

$$V_{2t} = \frac{\sigma^2}{\Delta_3} \int_0^{\Delta_3} c(\delta_2 + \Delta_2 - t + t')\,dt' \qquad (13)$$

$$= \sigma^2 \left[a + \frac{b}{\Delta_3} \{(\delta_2+\Delta_2+\Delta_3-t)\ln(\delta_2+\Delta_2+\Delta_3-t) - (\delta_2+\Delta_2-t)\ln(\delta_2+\Delta_2-t) - \Delta_3\} \right]$$

$$V_{12} = \frac{\sigma^2}{\Delta_1} \int_0^{\Delta_1} dt \, \frac{1}{\Delta_3} \int_0^{\Delta_3} c(\delta_1+\delta_2+\Delta_1+\Delta_2+t'-t)\, dt'$$

$$= \frac{\sigma^2}{\Delta_1} \int_0^{\Delta_1} dt \, \frac{1}{\Delta_3} \int_0^{\Delta_3} \left\{a+b\ln(\delta_1+\delta_2+\Delta_1+\Delta_2+t'-t)\right\} dt'$$

$$= \frac{\sigma^2}{\Delta_1} \int_0^{\Delta_1} dt \left\{a + \frac{b}{\Delta_3} [(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3-t)\ln(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3-t)\right.$$

$$\left. - (\delta_1+\delta_2+\Delta_1+\Delta_2-t \, \ln(\delta_1+\delta_2+\Delta_1+\Delta_2-t) - \Delta_3]\right\}$$

$$= \sigma^2 \left\{ a + \frac{b}{\Delta_1\Delta_3} \left[\frac{(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3)^2}{2} \ln(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3) \right.\right.$$

$$- \frac{(\delta_1+\delta_2+\Delta_2+\Delta_3)^2}{2} \ln(\delta_1+\delta_2+\Delta_2+\Delta_3) - \frac{\Delta_1}{4} [2(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3)-\Delta_1]$$

$$- \frac{(\delta_1+\delta_2+\Delta_1+\Delta_2)^2}{2} \ln(\delta_1+\delta_2+\Delta_1+\Delta_2)$$

$$\left.\left. + \frac{(\delta_1+\delta_2+\Delta_2)^2}{2} \ln(\delta_1+\delta_2+\Delta_2) + \frac{\Delta_1}{4} (2\delta_1+2\delta_2+2\Delta_1+2\Delta_2-\Delta_1)-\Delta_1\Delta_3 \right]\right\}$$

$$V_{12} = \sigma^2 \left\{ a + \frac{b}{\Delta_1\Delta_3} \left[\frac{(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3)^2}{2} \ln(\delta_1+\delta_2+\Delta_1+\Delta_2+\Delta_3) \right.\right.$$

$$- \frac{(\delta_1+\delta_2+\Delta_2+\Delta_3)^2}{2} \ln(\delta_1+\delta_2+\Delta_2+\Delta_3)$$

$$- \frac{(\delta_1+\delta_2+\Delta_1+\Delta_2)^2}{2} \ln(\delta_1+\delta_2+\Delta_1+\Delta_2)$$

$$\left.\left. + \frac{(\delta_1+\delta_2+\Delta_2)^2}{2} \ln(\delta_1+\delta_2+\Delta_2) - \frac{3}{2} \Delta_1\Delta_3 \right]\right\}$$

ıTION PROCEDURE ON VARIANCE OF NOISE RADIANCE DA1

)S-01/18/74-11:57:28 NAMES

Program to compute variance of noise for different set of values for DELTA1, DEL1, DEL2, DELTA3.

:

000122
000403

ERENCES:

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GNMENT:

1	100L	0		000031	1005F	0		000044	1010F	0		000057	1020F
0	1060F	1		000047	110G	1		000130	110L	1		000137	120L
6	137G	1		000154	140L	1		000062	60L	1		000066	80L
1	B	0	R	000000	BETA	0	R	000005	DELTA1	0	R	000007	DELTA3
6	DEL2	0	I	000004	I	0	I	000003	J	0	I	000011	L
2	V1	0	R	000014	V1T	0	R	000016	V12	0	R	000013	V2

```
      BETA=.5
      B=-.006
      A=.006
 50   DO 1000 J=1,2
      DO 1000 I=1,4
      DELTA1=.03
      DEL2=.016
      IF(J.EQ.2) GO TO 60
      DELTA3=.04
      DEL1=.016
      GO TO 80
 60   DEL1=.05
      DELTA3=.1
 80   PRINT 1060,A,B
1060  FORMAT(1H1,10X,'CTAU=',F9.8,' + ',F9.6,'*ALOG(TAU)')
      PRINT 1005
1005  FORMAT('      VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12')
      PRINT 1010
1010  FORMAT(//7X,'DELTA1     DEL1     DEL2     DELTA3     VAR/(ALPHASQ*SIGS
     1Q)')
      DO 1000 L=1,40
      GO TO (100,110,120,130),I
100   DELTA1=.02+.003*L
      GO TO 140
```

BRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

```
  110   DEL1=.008+.003*L
        GO TO 140
    0   DEL2=.008+.003*L
        GO TO 140
  130   DELTA3=.02+.003*L
  140     V1=A+B*ALOG(DELTA1)-1.5*B
          V2=A+B*ALOG(DELTA3)-1.5*B
        V1T=A+B/DELTA1*((.015+DEL1+DELTA1)*ALOG(.015+DEL1+DELTA1)-(.015+
       1DEL1)*ALOG(.015+DEL1)-DELTA1)
        V2T=A+B/DELTA3*((.015+DEL2+DELTA3)*ALOG(.015+DEL2+DELTA3)-(.015+
       1DEL2)*ALOG(.015+DEL2)-DELTA3)
        V12=A+.5*B/(DELTA1*DELTA3)*((DEL1+DEL2+DELTA1+DELTA3+.03)**2*ALOG(
       1DEL1+DEL2+DELTA1+DELTA3+.03)-(DEL1+DEL2+DELTA3+.03)**2*ALOG(DEL1+
       2DEL2+DELTA3+.03)-(DEL1+DEL2+DELTA1+.03)**2*ALOG(DEL1+DEL2+DELTA1+
       3.03)+(DEL1+DEL2+.03)**2*ALOG(DEL1+DEL2+.03)-3*DELTA1*DELTA3)
        VAR=1+(1-BETA)**2*V1+BETA**2*V2-2*(1-BETA)*V1T+2*BETA*(1-BETA)*
       1V12-2*BETA*V2T
        PRINT 1020,DELTA1,DEL1,DEL2,DELTA3,VAR
 1020   FORMAT(5X,4(3PF7.2,2X),2X,0PF10.6)
 1000   CONTINUE
        STOP
        END
```

OMPILATION: NO DIAGNOSTICS.

EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02870000 + -.027200*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

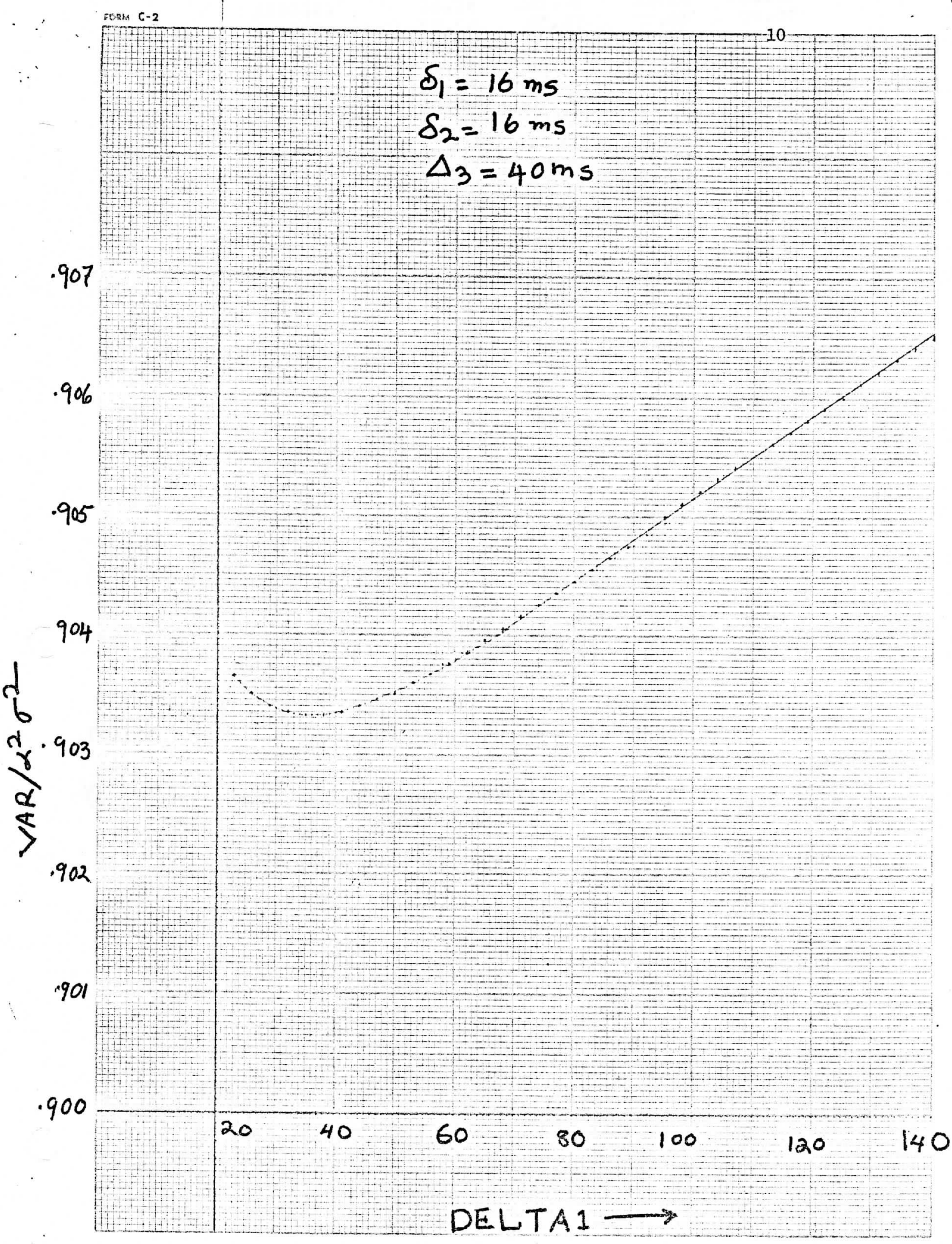
FMIN = .026 Hz FMAX = 17450 Hz FC = 750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
23.00	16.00	16.00	40.00	.903689
26.00	16.00	16.00	40.00	.903521
29.00	16.00	16.00	40.00	.903414
32.00	16.00	16.00	40.00	.903354
35.00	16.00	16.00	40.00	.903330
38.00	16.00	16.00	40.00	.903334
41.00	16.00	16.00	40.00	.903359
44.00	16.00	16.00	40.00	.903401
47.00	16.00	16.00	40.00	.903456
50.00	16.00	16.00	40.00	.903523
53.00	16.00	16.00	40.00	.903598
56.00	16.00	16.00	40.00	.903681
59.00	16.00	16.00	40.00	.903769
62.00	16.00	16.00	40.00	.903862
65.00	16.00	16.00	40.00	.903958
68.00	16.00	16.00	40.00	.904057
71.00	16.00	16.00	40.00	.904158
74.00	16.00	16.00	40.00	.904261
77.00	16.00	16.00	40.00	.904365
80.00	16.00	16.00	40.00	.904470
83.00	16.00	16.00	40.00	.904576
86.00	16.00	16.00	40.00	.904682
89.00	16.00	16.00	40.00	.904788
92.00	16.00	16.00	40.00	.904895
95.00	16.00	16.00	40.00	.905001
98.00	16.00	16.00	40.00	.905106
101.00	16.00	16.00	40.00	.905211
104.00	16.00	16.00	40.00	.905316
107.00	16.00	16.00	40.00	.905420
110.00	16.00	16.00	40.00	.905524
113.00	16.00	16.00	40.00	.905626
116.00	16.00	16.00	40.00	.905728
119.00	16.00	16.00	40.00	.905830
122.00	16.00	16.00	40.00	.905930
125.00	16.00	16.00	40.00	.906030
128.00	16.00	16.00	40.00	.906128
131.00	16.00	16.00	40.00	.906226
134.00	16.00	16.00	40.00	.906323
137.00	16.00	16.00	40.00	.906419
140.00	16.00	16.00	40.00	.906514

min. Δ_1 δ_1 .03 δ_2 Δ_3

max.

space earth shutter


FORM C-2
10
$\delta_1 = 16$ ms
$\delta_2 = 16$ ms
$\Delta_3 = 40$ ms
.907
.906
.905
.904
.903
.902
.901
.900
$VAR/\gamma^2\sigma^2$
20
40
60
80
100
120
140
DELTA1 →

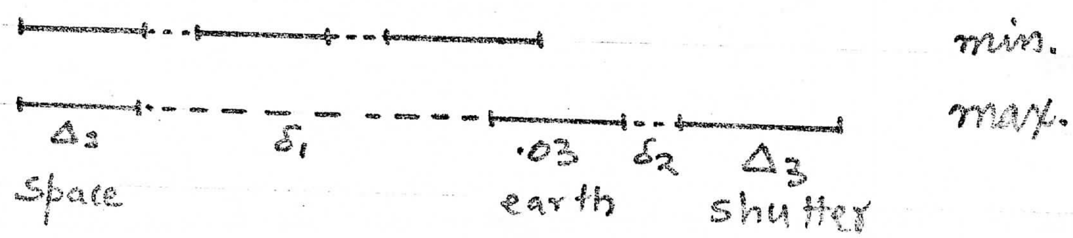
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02870000 + -.027200*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN=.026 Hz FMAX=17450 Hz FC=750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	11.00	16.00	40.00	.900863
30.00	14.00	16.00	40.00	.902423
30.00	17.00	16.00	40.00	.903854
30.00	20.00	16.00	40.00	.905175
30.00	23.00	16.00	40.00	.906400
30.00	26.00	16.00	40.00	.907543
30.00	29.00	16.00	40.00	.908613
30.00	32.00	16.00	40.00	.909619
30.00	35.00	16.00	40.00	.910557
30.00	38.00	16.00	40.00	.911463
30.00	41.00	16.00	40.00	.912312
30.00	44.00	16.00	40.00	.913119
30.00	47.00	16.00	40.00	.913888
30.00	50.00	16.00	40.00	.914621
30.00	53.00	16.00	40.00	.915323
30.00	56.00	16.00	40.00	.915994
30.00	59.00	16.00	40.00	.916638
30.00	62.00	16.00	40.00	.917257
30.00	65.00	16.00	40.00	.917852
30.00	68.00	16.00	40.00	.918425
30.00	71.00	16.00	40.00	.918978
30.00	74.00	16.00	40.00	.919512
30.00	77.00	16.00	40.00	.920028
30.00	80.00	16.00	40.00	.920527
30.00	83.00	16.00	40.00	.921010
30.00	86.00	16.00	40.00	.921478
30.00	89.00	16.00	40.00	.921933
30.00	92.00	16.00	40.00	.922374
30.00	95.00	16.00	40.00	.922802
30.00	98.00	16.00	40.00	.923219
30.00	101.00	16.00	40.00	.923625
30.00	104.00	16.00	40.00	.924019
30.00	107.00	16.00	40.00	.924404
30.00	110.00	16.00	40.00	.924779
30.00	113.00	16.00	40.00	.925145
30.00	116.00	16.00	40.00	.925502
30.00	119.00	16.00	40.00	.925850
30.00	122.00	16.00	40.00	.926191
30.00	125.00	16.00	40.00	.926523
30.00	128.00	16.00	40.00	.926849



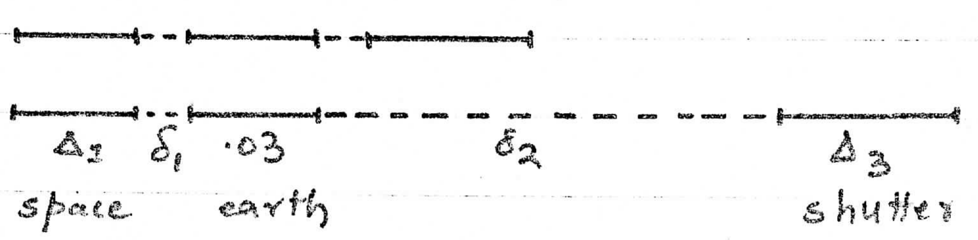
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02870000 + -.027200*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN= .026 Hz FMAX= 17450 Hz FC= 750 Hz

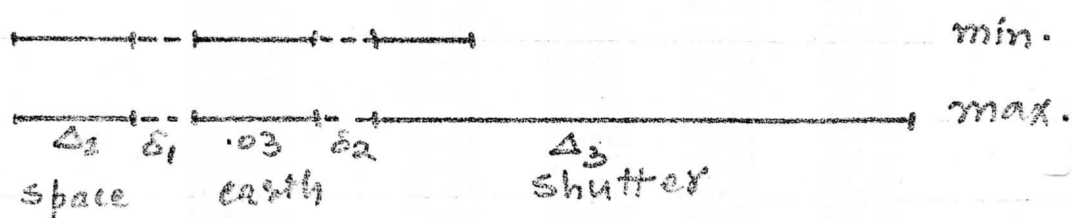
DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	16.00	11.00	40.00	.901142
30.00	16.00	14.00	40.00	.902527
30.00	16.00	17.00	40.00	.903604
30.00	16.00	20.00	40.00	.904989
30.00	16.00	23.00	40.00	.906092
30.00	16.00	26.00	40.00	.907125
30.00	16.00	29.00	40.00	.908096
30.00	16.00	32.00	40.00	.909010
30.00	16.00	35.00	40.00	.909875
30.00	16.00	38.00	40.00	.910695
30.00	16.00	41.00	40.00	.911475
30.00	16.00	44.00	40.00	.912217
30.00	16.00	47.00	40.00	.912926
30.00	16.00	50.00	40.00	.913603
30.00	16.00	53.00	40.00	.914252
30.00	16.00	56.00	40.00	.914875
30.00	16.00	59.00	40.00	.915474
30.00	16.00	62.00	40.00	.916050
30.00	16.00	65.00	40.00	.916605
30.00	16.00	68.00	40.00	.917140
30.00	16.00	71.00	40.00	.917657
30.00	16.00	74.00	40.00	.918157
30.00	16.00	77.00	40.00	.918641
30.00	16.00	80.00	40.00	.919109
30.00	16.00	83.00	40.00	.919564
30.00	16.00	86.00	40.00	.920004
30.00	16.00	89.00	40.00	.920433
30.00	16.00	92.00	40.00	.920849
30.00	16.00	95.00	40.00	.921254
30.00	16.00	98.00	40.00	.921648
30.00	16.00	101.00	40.00	.922031
30.00	16.00	104.00	40.00	.922405
30.00	16.00	107.00	40.00	.922770
30.00	16.00	110.00	40.00	.923126
30.00	16.00	113.00	40.00	.923473
30.00	16.00	116.00	40.00	.923813
30.00	16.00	119.00	40.00	.924144
30.00	16.00	122.00	40.00	.924468
30.00	16.00	125.00	40.00	.924785
30.00	16.00	128.00	40.00	.925096
ms	ms	ms	ms	

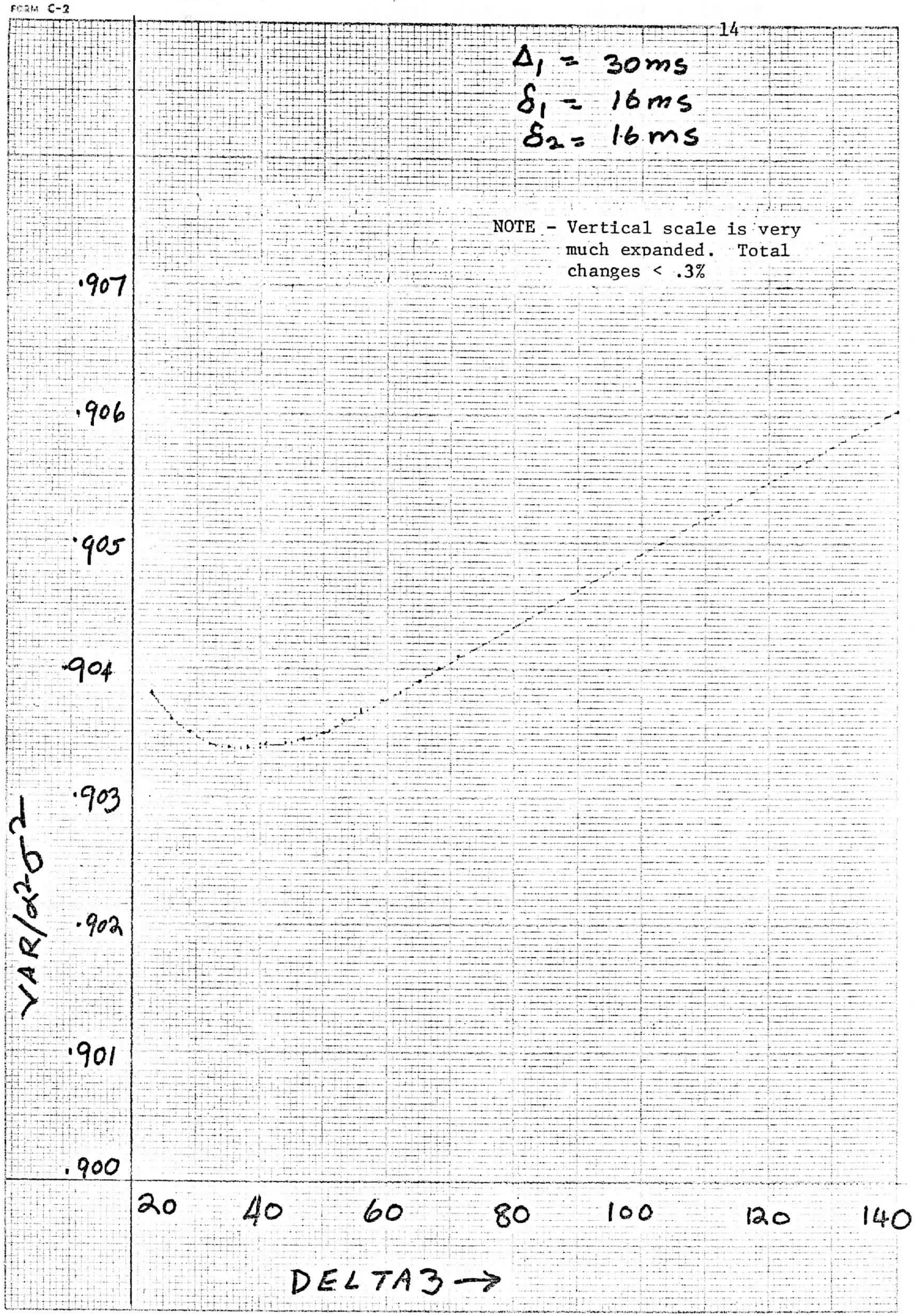


EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02870000 + -.027200*ALOG(TAU)
VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12
FMIN=.026 Hz FMAX=17450 FC=750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	16.00	16.00	23.00	.903784
30.00	16.00	16.00	26.00	.903605
30.00	16.00	16.00	29.00	.903489
30.00	16.00	16.00	32.00	.903420
30.00	16.00	16.00	35.00	.903386
30.00	16.00	16.00	38.00	.903381
30.00	16.00	16.00	41.00	.903397
30.00	16.00	16.00	44.00	.903431
30.00	16.00	16.00	47.00	.903479
30.00	16.00	16.00	50.00	.903538
30.00	16.00	16.00	53.00	.903606
30.00	16.00	16.00	56.00	.903681
30.00	16.00	16.00	59.00	.903762
30.00	16.00	16.00	62.00	.903848
30.00	16.00	16.00	65.00	.903937
30.00	16.00	16.00	68.00	.904030
30.00	16.00	16.00	71.00	.904125
30.00	16.00	16.00	74.00	.904221
30.00	16.00	16.00	77.00	.904320
30.00	16.00	16.00	80.00	.904419
30.00	16.00	16.00	83.00	.904519
30.00	16.00	16.00	86.00	.904620
30.00	16.00	16.00	89.00	.904721
30.00	16.00	16.00	92.00	.904821
30.00	16.00	16.00	95.00	.904922
30.00	16.00	16.00	98.00	.905023
30.00	16.00	16.00	101.00	.905123
30.00	16.00	16.00	104.00	.905223
30.00	16.00	16.00	107.00	.905323
30.00	16.00	16.00	110.00	.905422
30.00	16.00	16.00	113.00	.905520
30.00	16.00	16.00	116.00	.905617
30.00	16.00	16.00	119.00	.905714
30.00	16.00	16.00	122.00	.905811
30.00	16.00	16.00	125.00	.905906
30.00	16.00	16.00	128.00	.906001
30.00	16.00	16.00	131.00	.906094
30.00	16.00	16.00	134.00	.906187
30.00	16.00	16.00	137.00	.906280
30.00	16.00	16.00	140.00	.906371
ms	ms	ms	ms	




FORM C-2
Δ_1 = 30ms
δ_1 = 16ms
δ_2 = 16ms
NOTE - Vertical scale is very much expanded. Total changes < .3%
.907
.906
.905
.904
.903
.902
.901
.900
VAR/$\alpha^2\sigma^2$
20
40
60
80
100
120
140
DELTA3 →

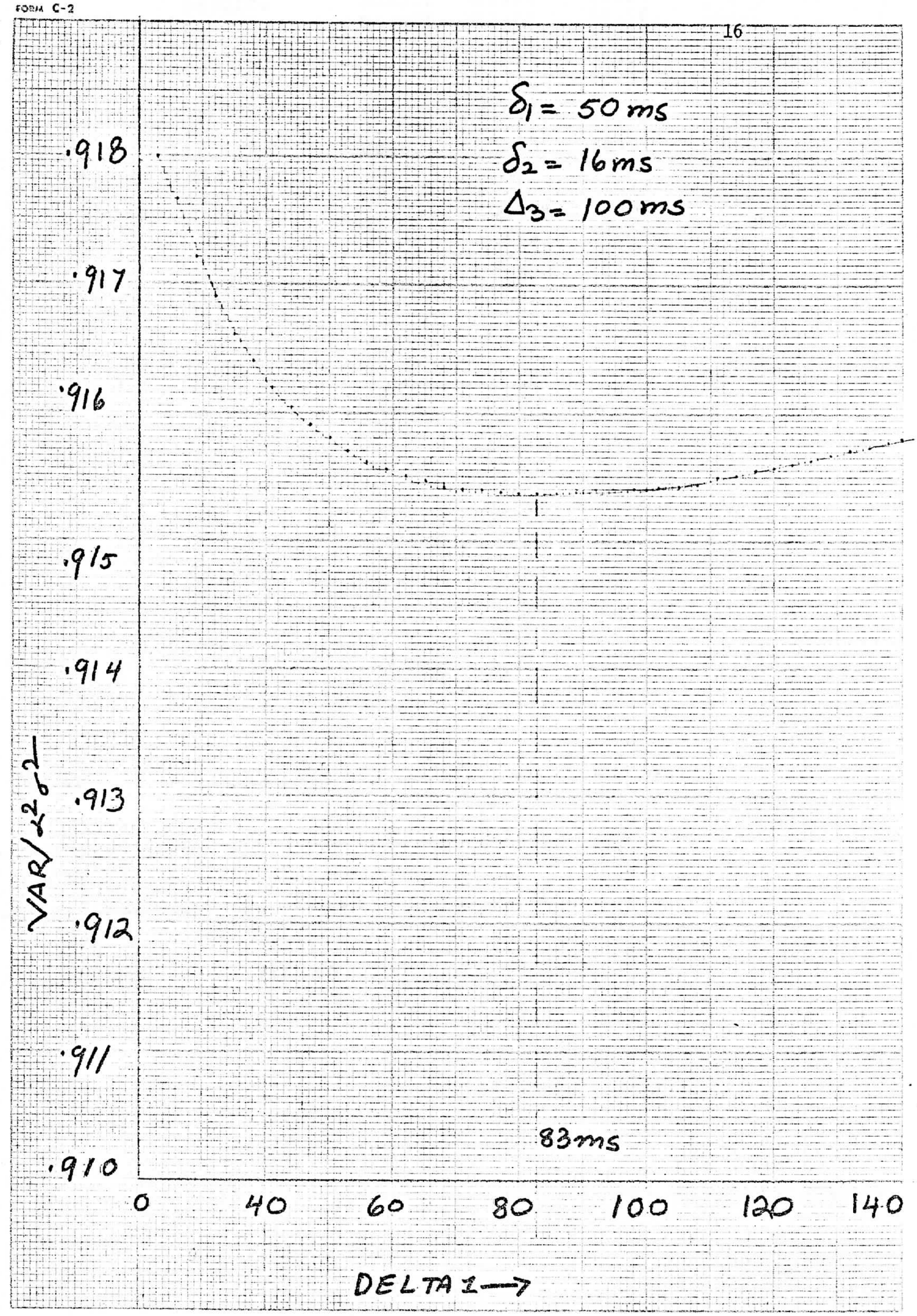
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02370000 + -.027200*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN= .02 Hz FMAX=17450 Hz FC=750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
23.00	50.00	16.00	100.00	.918042
26.00	50.00	16.00	100.00	.917583
29.00	50.00	16.00	100.00	.917205
32.00	50.00	16.00	100.00	.916890
35.00	50.00	16.00	100.00	.916627
38.00	50.00	16.00	100.00	.916405
41.00	50.00	16.00	100.00	.916218
44.00	50.00	16.00	100.00	.916059
47.00	50.00	16.00	100.00	.915925
50.00	50.00	16.00	100.00	.915812
53.00	50.00	16.00	100.00	.915717
56.00	50.00	16.00	100.00	.915637
59.00	50.00	16.00	100.00	.915570
62.00	50.00	16.00	100.00	.915515
65.00	50.00	16.00	100.00	.915471
68.00	50.00	16.00	100.00	.915435
71.00	50.00	16.00	100.00	.915408
74.00	50.00	16.00	100.00	.915387
77.00	50.00	16.00	100.00	.915373
80.00	50.00	16.00	100.00	.915365
83.00	50.00	16.00	100.00	.915362
86.00	50.00	16.00	100.00	.915363
89.00	50.00	16.00	100.00	.915369
92.00	50.00	16.00	100.00	.915378
95.00	50.00	16.00	100.00	.915390
98.00	50.00	16.00	100.00	.915406
101.00	50.00	16.00	100.00	.915424
104.00	50.00	16.00	100.00	.915445
107.00	50.00	16.00	100.00	.915468
110.00	50.00	16.00	100.00	.915493
113.00	50.00	16.00	100.00	.915520
116.00	50.00	16.00	100.00	.915548
119.00	50.00	16.00	100.00	.915578
122.00	50.00	16.00	100.00	.915609
125.00	50.00	16.00	100.00	.915642
128.00	50.00	16.00	100.00	.915676
131.00	50.00	16.00	100.00	.915711
134.00	50.00	16.00	100.00	.915746
137.00	50.00	16.00	100.00	.915783
140.00	50.00	16.00	100.00	.915821


FORM C-2
δ_1 = 50 ms
δ_2 = 16 ms
Δ_3 = 100 ms
.918
.917
.916
.915
.914
.913
.912
.911
.910
VAR/$\alpha^2\sigma^2$
83 ms
0
40
60
80
100
120
140
DELTA 1 →

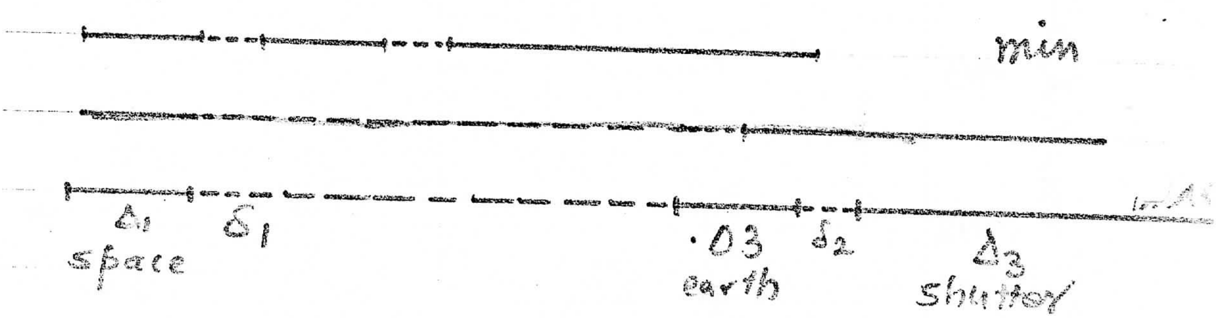
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02870000 + -.027200*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN= .026 Hz FMAX= 17450 Hz FC=750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	11.00	16.00	100.00	.902408
30.00	14.00	16.00	100.00	.904063
30.00	17.00	16.00	100.00	.905583
30.00	20.00	16.00	100.00	.906939
30.00	23.00	16.00	100.00	.908295
30.00	26.00	16.00	100.00	.909515
30.00	29.00	16.00	100.00	.910658
30.00	32.00	16.00	100.00	.911733
30.00	35.00	16.00	100.00	.912747
30.00	38.00	16.00	100.00	.913707
30.00	41.00	16.00	100.00	.914617
30.00	44.00	16.00	100.00	.915482
30.00	47.00	16.00	100.00	.916307
30.00	50.00	16.00	100.00	.917093
30.00	53.00	16.00	100.00	.917846
30.00	56.00	16.00	100.00	.918567
30.00	59.00	16.00	100.00	.919258
30.00	62.00	16.00	100.00	.919923
30.00	65.00	16.00	100.00	.920562
30.00	68.00	16.00	100.00	.921178
30.00	71.00	16.00	100.00	.921771
30.00	74.00	16.00	100.00	.922345
30.00	77.00	16.00	100.00	.922899
30.00	80.00	16.00	100.00	.923434
30.00	83.00	16.00	100.00	.923953
30.00	86.00	16.00	100.00	.924456
30.00	89.00	16.00	100.00	.924944
30.00	92.00	16.00	100.00	.925418
30.00	95.00	16.00	100.00	.925878
30.00	98.00	16.00	100.00	.926325
30.00	101.00	16.00	100.00	.926760
30.00	104.00	16.00	100.00	.927183
30.00	107.00	16.00	100.00	.927596
30.00	110.00	16.00	100.00	.927998
30.00	113.00	16.00	100.00	.928390
30.00	116.00	16.00	100.00	.928772
30.00	119.00	16.00	100.00	.929146
30.00	122.00	16.00	100.00	.929510
30.00	125.00	16.00	100.00	.929867
30.00	128.00	16.00	100.00	.930215



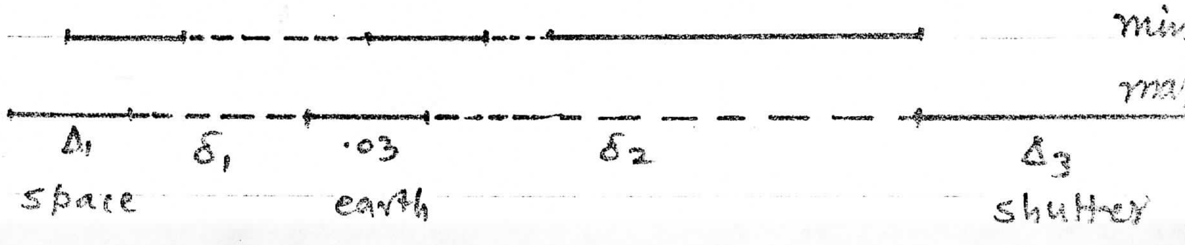
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.02870000 + -.027200*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN= .026 Hz FMAX= 17450 Hz FC= 750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	50.00	11.00	100.00	.915489
30.00	50.00	14.00	100.00	.916472
30.00	50.00	17.00	100.00	.917395
30.00	50.00	20.00	100.00	.918265
30.00	50.00	23.00	100.00	.919087
30.00	50.00	26.00	100.00	.919868
30.00	50.00	29.00	100.00	.920612
30.00	50.00	32.00	100.00	.921320
30.00	50.00	35.00	100.00	.921998
30.00	50.00	38.00	100.00	.922647
30.00	50.00	41.00	100.00	.923270
30.00	50.00	44.00	100.00	.923869
30.00	50.00	47.00	100.00	.924446
30.00	50.00	50.00	100.00	.925001
30.00	50.00	53.00	100.00	.925537
30.00	50.00	56.00	100.00	.926055
30.00	50.00	59.00	100.00	.926557
30.00	50.00	62.00	100.00	.927042
30.00	50.00	65.00	100.00	.927512
30.00	50.00	68.00	100.00	.927969
30.00	50.00	71.00	100.00	.928412
30.00	50.00	74.00	100.00	.928843
30.00	50.00	77.00	100.00	.929261
30.00	50.00	80.00	100.00	.929669
30.00	50.00	83.00	100.00	.930066
30.00	50.00	86.00	100.00	.930452
30.00	50.00	89.00	100.00	.930829
30.00	50.00	92.00	100.00	.931197
30.00	50.00	95.00	100.00	.931556
30.00	50.00	98.00	100.00	.931907
30.00	50.00	101.00	100.00	.932250
30.00	50.00	104.00	100.00	.932585
30.00	50.00	107.00	100.00	.932913
30.00	50.00	110.00	100.00	.933234
30.00	50.00	113.00	100.00	.933548
30.00	50.00	116.00	100.00	.933855
30.00	50.00	119.00	100.00	.934156
30.00	50.00	122.00	100.00	.934452
30.00	50.00	125.00	100.00	.934741
30.00	50.00	128.00	100.00	.935025



EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

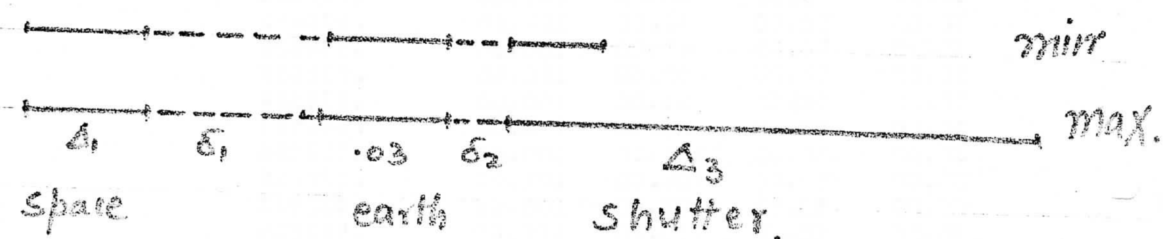
CTAU=.02870000 + -.027200*ALOG(TAU)

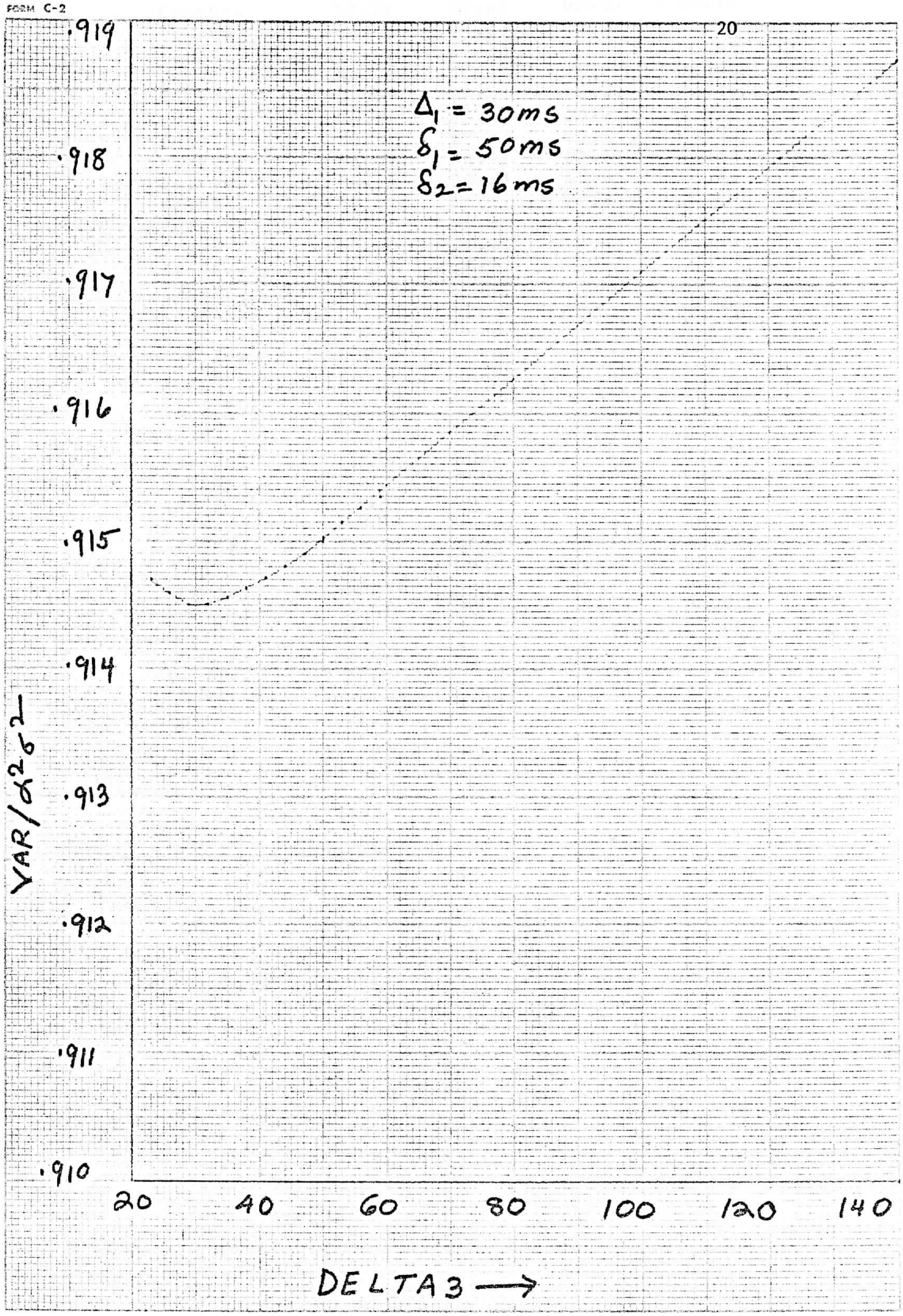
VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN=.026 FMAX=17450 Hz Fc=750 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	50.00	16.00	23.00	.914701
30.00	50.00	16.00	26.00	.914582
30.00	50.00	16.00	29.00	.914524
30.00	50.00	16.00	32.00	.914511
30.00	50.00	16.00	35.00	.914532
30.00	50.00	16.00	38.00	.914579
30.00	50.00	16.00	41.00	.914646
30.00	50.00	16.00	44.00	.914729
30.00	50.00	16.00	47.00	.914824
30.00	50.00	16.00	50.00	.914929
30.00	50.00	16.00	53.00	.915042
30.00	50.00	16.00	56.00	.915161
30.00	50.00	16.00	59.00	.915284
30.00	50.00	16.00	62.00	.915411
30.00	50.00	16.00	65.00	.915541
30.00	50.00	16.00	68.00	.915673
30.00	50.00	16.00	71.00	.915806
30.00	50.00	16.00	74.00	.915939
30.00	50.00	16.00	77.00	.916074
30.00	50.00	16.00	80.00	.916208
30.00	50.00	16.00	83.00	.916343
30.00	50.00	16.00	86.00	.916477
30.00	50.00	16.00	89.00	.916610
30.00	50.00	16.00	92.00	.916743
30.00	50.00	16.00	95.00	.916875
30.00	50.00	16.00	98.00	.917007
30.00	50.00	16.00	101.00	.917137
30.00	50.00	16.00	104.00	.917266
30.00	50.00	16.00	107.00	.917394
30.00	50.00	16.00	110.00	.917521
30.00	50.00	16.00	113.00	.917646
30.00	50.00	16.00	116.00	.917771
30.00	50.00	16.00	119.00	.917894
30.00	50.00	16.00	122.00	.918016
30.00	50.00	16.00	125.00	.918136
30.00	50.00	16.00	128.00	.918256
30.00	50.00	16.00	131.00	.918374
30.00	50.00	16.00	134.00	.918491
30.00	50.00	16.00	137.00	.918606
30.00	50.00	16.00	140.00	.918720

@FIN



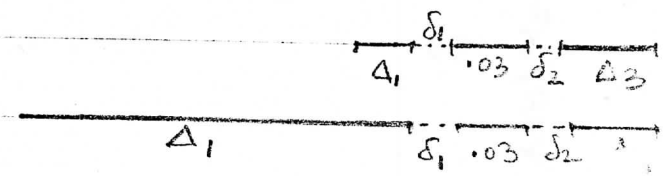

20
Δ1 = 30ms
δ1 = 50ms
δ2 = 16ms
.919
.918
.917
.916
.915
.914
.913
.912
.911
.910
VAR/δ²σ²
20
40
60
80
100
120
140
DELTA3 ⟶

EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

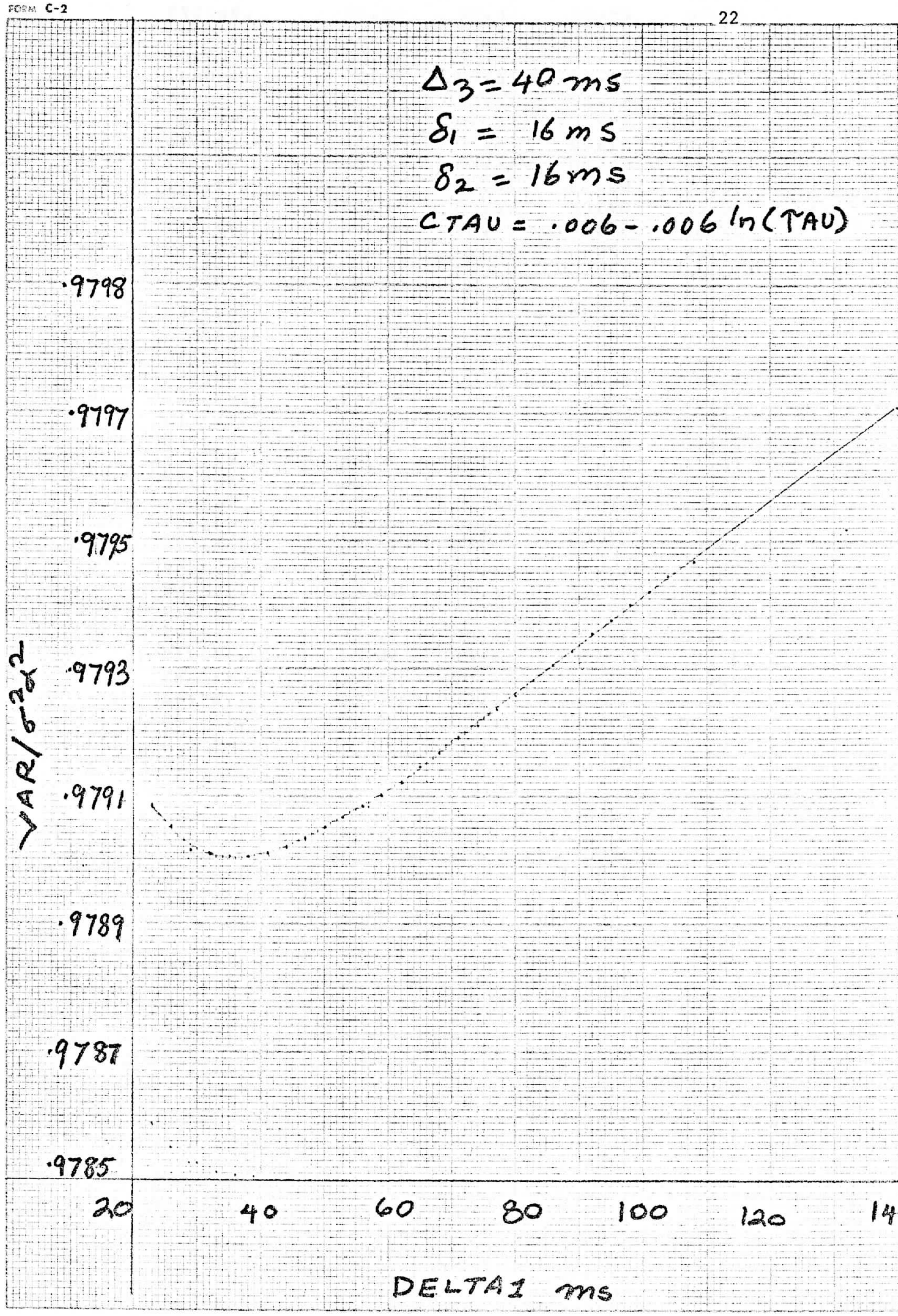
CTAU=.00600000 + -.006000*ALOG(TAU)
VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FMIN=.026 FMAX 17250 Fc= 10 hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
23.00	16.00	16.00	40.00	.979086
26.00	16.00	16.00	40.00	.979049
29.00	16.00	16.00	40.00	.979025
32.00	16.00	16.00	40.00	.979012
35.00	16.00	16.00	40.00	.979007
38.00	16.00	16.00	40.00	.979007
41.00	16.00	16.00	40.00	.979013
44.00	16.00	16.00	40.00	.979022
47.00	16.00	16.00	40.00	.979034
50.00	16.00	16.00	40.00	.979049
53.00	16.00	16.00	40.00	.979066
56.00	16.00	16.00	40.00	.979084
59.00	16.00	16.00	40.00	.979103
62.00	16.00	16.00	40.00	.979124
65.00	16.00	16.00	40.00	.979145
68.00	16.00	16.00	40.00	.979167
71.00	16.00	16.00	40.00	.979189
74.00	16.00	16.00	40.00	.979212
77.00	16.00	16.00	40.00	.979235
80.00	16.00	16.00	40.00	.979258
83.00	16.00	16.00	40.00	.979281
86.00	16.00	16.00	40.00	.979305
89.00	16.00	16.00	40.00	.979328
92.00	16.00	16.00	40.00	.979352
95.00	16.00	16.00	40.00	.979375
98.00	16.00	16.00	40.00	.979398
101.00	16.00	16.00	40.00	.979422
104.00	16.00	16.00	40.00	.979445
107.00	16.00	16.00	40.00	.979468
110.00	16.00	16.00	40.00	.979491
113.00	16.00	16.00	40.00	.979513
116.00	16.00	16.00	40.00	.979536
119.00	16.00	16.00	40.00	.979558
122.00	16.00	16.00	40.00	.979530
125.00	16.00	16.00	40.00	.979602
128.00	16.00	16.00	40.00	.979624
131.00	16.00	16.00	40.00	.979645
134.00	16.00	16.00	40.00	.979667
137.00	16.00	16.00	40.00	.979688
140.00	16.00	16.00	40.00	.979709



FORM C-2


Δ3 = 40 ms
δ1 = 16 ms
δ2 = 16 ms
CTAU = .006 - .006 ln(TAU)
.9798
.9797
.9795
.9793
.9791
.9789
.9787
.9785
VAR/σ²γ²
20
40
60
80
100
120
140
DELTA1 ms

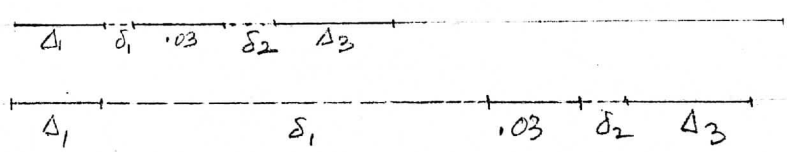
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.00600000 + -.006000*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FC= 10Hz FMAX= 17450Hz FMIN= .026 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	11.00	16.00	40.00	.978462
30.00	14.00	16.00	40.00	.978806
30.00	17.00	16.00	40.00	.979122
30.00	20.00	16.00	40.00	.979413
30.00	23.00	16.00	40.00	.979684
30.00	26.00	16.00	40.00	.979936
30.00	29.00	16.00	40.00	.980172
30.00	32.00	16.00	40.00	.980394
30.00	35.00	16.00	40.00	.980603
30.00	38.00	16.00	40.00	.960801
30.00	41.00	16.00	40.00	.980988
30.00	44.00	16.00	40.00	.981166
30.00	47.00	16.00	40.00	.981336
30.00	50.00	16.00	40.00	.981497
30.00	53.00	16.00	40.00	.981652
30.00	56.00	16.00	40.00	.981800
30.00	59.00	16.00	40.00	.981942
30.00	62.00	16.00	40.00	.982079
30.00	65.00	16.00	40.00	.982210
30.00	68.00	16.00	40.00	.982336
30.00	71.00	16.00	40.00	.982458
30.00	74.00	16.00	40.00	.982576
30.00	77.00	16.00	40.00	.982690
30.00	80.00	16.00	40.00	.982600
30.00	83.00	16.00	40.00	.982907
30.00	86.00	16.00	40.00	.983010
30.00	89.00	16.00	40.00	.983110
30.00	92.00	16.00	40.00	.983207
30.00	95.00	16.00	40.00	.983302
30.00	98.00	16.00	40.00	.983394
30.00	101.00	16.00	40.00	.983483
30.00	104.00	16.00	40.00	.983570
30.00	107.00	16.00	40.00	.983655
30.00	110.00	16.00	40.00	.983738
30.00	113.00	16.00	40.00	.983819
30.00	116.00	16.00	40.00	.983897
30.00	119.00	16.00	40.00	.983974
30.00	122.00	16.00	40.00	.984049
30.00	125.00	16.00	40.00	.984123
30.00	128.00	16.00	40.00	.984195



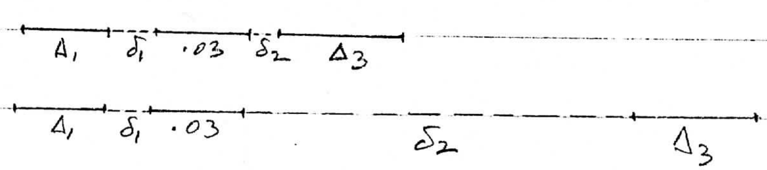
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

CTAU=.00600000 + -.006000*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FC=10 Hz FMAX= 17450 Hz FMIN= .026 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	16.00	11.00	40.00	.978524
30.00	16.00	14.00	40.00	.978830
30.00	16.00	17.00	40.00	.979111
30.00	16.00	20.00	40.00	.979372
30.00	16.00	23.00	40.00	.979616
30.00	16.00	26.00	40.00	.979844
30.00	16.00	29.00	40.00	.980058
30.00	16.00	32.00	40.00	.980260
30.00	16.00	35.00	40.00	.980450
30.00	16.00	38.00	40.00	.980631
30.00	16.00	41.00	40.00	.980803
30.00	16.00	44.00	40.00	.980967
30.00	16.00	47.00	40.00	.981123
30.00	16.00	50.00	40.00	.981273
30.00	16.00	53.00	40.00	.981416
30.00	16.00	56.00	40.00	.981553
30.00	16.00	59.00	40.00	.981685
30.00	16.00	62.00	40.00	.981812
30.00	16.00	65.00	40.00	.981935
30.00	16.00	68.00	40.00	.982053
30.00	16.00	71.00	40.00	.982167
30.00	16.00	74.00	40.00	.982277
30.00	16.00	77.00	40.00	.982384
30.00	16.00	80.00	40.00	.982487
30.00	16.00	83.00	40.00	.982588
30.00	16.00	86.00	40.00	.982685
30.00	16.00	89.00	40.00	.982779
30.00	16.00	92.00	40.00	.982871
30.00	16.00	95.00	40.00	.982960
30.00	16.00	98.00	40.00	.983047
30.00	16.00	101.00	40.00	.983132
30.00	16.00	104.00	40.00	.983214
30.00	16.00	107.00	40.00	.983295
30.00	16.00	110.00	40.00	.983373
30.00	16.00	113.00	40.00	.983450
30.00	16.00	116.00	40.00	.983525
30.00	16.00	119.00	40.00	.983598
30.00	16.00	122.00	40.00	.983669
30.00	16.00	125.00	40.00	.983739
30.00	16.00	128.00	40.00	.983808



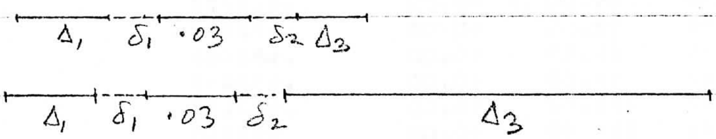
EFFECT OF CALIBRATION PROCEDURE ON VARIANCE OF NOISE RADIANCE

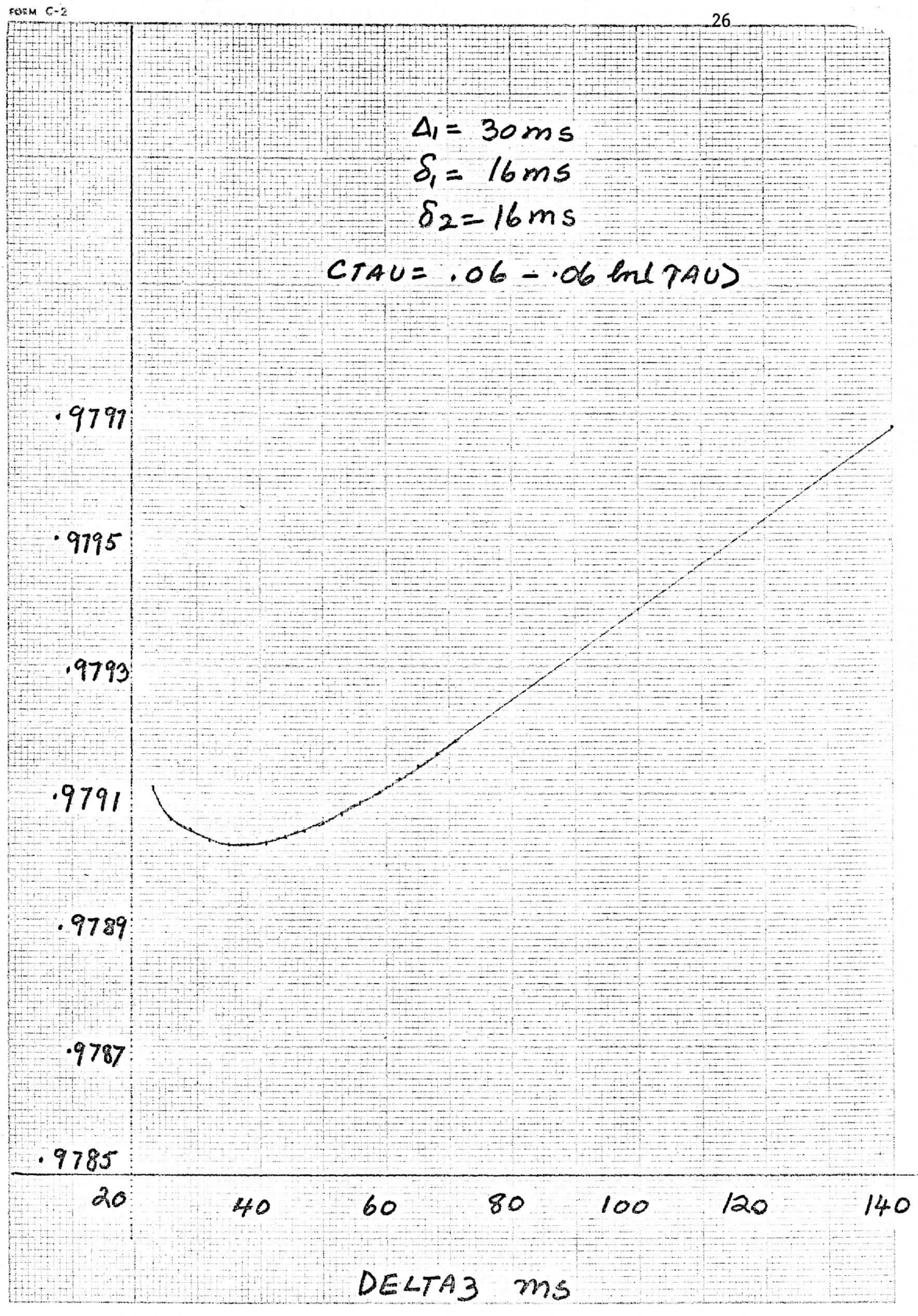
CTAU=.00600000 + -.006000*ALOG(TAU)

VAR/(ALPHASQ*SIGMASQ)=1+.25(V1+V2)-(V1T+V2T)+.5V12

FC=10 Hz FMAX= 17450Hz FMIN= .026 Hz

DELTA1	DEL1	DEL2	DELTA3	VAR/(ALPHASQ*SIGSQ)
30.00	16.00	16.00	23.00	.979107
30.00	16.00	16.00	26.00	.979067
30.00	16.00	16.00	29.00	.979042
30.00	16.00	16.00	32.00	.979026
30.00	16.00	16.00	35.00	.979019
30.00	16.00	16.00	38.00	.979018
30.00	16.00	16.00	41.00	.979021
30.00	16.00	16.00	44.00	.979029
30.00	16.00	16.00	47.00	.979039
30.00	16.00	16.00	50.00	.979052
30.00	16.00	16.00	53.00	.979067
30.00	16.00	16.00	56.00	.979084
30.00	16.00	16.00	59.00	.979102
30.00	16.00	16.00	62.00	.979121
30.00	16.00	16.00	65.00	.979141
30.00	16.00	16.00	68.00	.979161
30.00	16.00	16.00	71.00	.979182
30.00	16.00	16.00	74.00	.979203
30.00	16.00	16.00	77.00	.979225
30.00	16.00	16.00	80.00	.979247
30.00	16.00	16.00	83.00	.979269
30.00	16.00	16.00	86.00	.979291
30.00	16.00	16.00	89.00	.979313
30.00	16.00	16.00	92.00	.979336
30.00	16.00	16.00	95.00	.979358
30.00	16.00	16.00	98.00	.979380
30.00	16.00	16.00	101.00	.979402
30.00	16.00	16.00	104.00	.979424
30.00	16.00	16.00	107.00	.979446
30.00	16.00	16.00	110.00	.979468
30.00	16.00	16.00	113.00	.979490
30.00	16.00	16.00	116.00	.979511
30.00	16.00	16.00	119.00	.979533
30.00	16.00	16.00	122.00	.979554
30.00	16.00	16.00	125.00	.979575
30.00	16.00	16.00	128.00	.979596
30.00	16.00	16.00	131.00	.979616
30.00	16.00	16.00	134.00	.979637
30.00	16.00	16.00	137.00	.979657
30.00	16.00	16.00	140.00	.979677




FORM C-2
Δ1 = 30ms
δ1 = 16ms
δ2 = 16ms
CTAU = .06 - .06 ln(TAU)
.9797
.9795
.9793
.9791
.9789
.9787
.9785
20
40
60
80
100
120
140
DELTA3 ms

APPENDIX III

Gradient Projection Method for Minimization of Variance

```
C*************BLK1**********
         DOUBLE PRECISION FUNC,DUAL,GRAD,S,Y
         REAL NORMG,NORMS
         INTEGER ERR,VARACT
         LOGICAL TRACE
         COMMON /BLK101/NUMCON,NUMVAR
         COMMON /BLK102/EPSFES,EPSZRO,KIMEF,MAXIT,TAUMAX
         COMMON /BLK103/TRACE,IOPT(15)
         COMMON /BLK104/IT,KTIME,KTIMS,KONACT(150),VARACT(75)
         COMMON /BLK105/ERR,FUNC,NORMG,NORMS,STPLNG,TAU
         COMMON /BLK106/DUAL(225),GRAD(75),S(75),X(75)
C***************************
C*************BLK4**********
         REAL MATRIX
         INTEGER CONVNM,VARTYP
         LOGICAL CONACT
         COMMON /BLK401/MATRIX(150,75),CUB(150),CLB(150),VUB(75),VLB(75),
        *KONTYP(150),VARTYP(75)
         COMMON /BLK404/CNAME(150),VNAME(75),TITLE(13)
         COMMON /BLK405/CONVNM,CONCOF,CONACT
C***************************
C*************BLK7**********
         DOUBLE PRECISION GUNC
         COMMON /BLK701/NUMFNC,NUMNLC,NTOT
         COMMON /BLK702/EPSNLC,EPSNLP,NONLC,WATE(150),RATE(150)
         COMMON /BLK704/ITNLC,KCCON,KSNLC,KONNLC(150)
         COMMON /BLK706/GUNC(150)
C***************************
C*************BLK3**********
         DOUBLE PRECISION XSAVE,GRADSV,HQ
         REAL NORMHQ
         COMMON /BLK302/EPSHQ
         COMMON /BLK304/XSAVE(75),GRADSV(75),HQ(2850)
         COMMON /BLK305/NORMHQ
C***************************
          CALL AAA
    2    FORMAT(13A6)
         READ 2,TITLE
         NUMCON=2
         NUMVAR=4
         MATRIX(1,1)=1
         MATRIX(1,2)=1
         MATRIX(1,3)=1
         MATRIX(1,4)=1
         MATRIX(2,1)=0
         MATRIX(2,2)=0
         MATRIX(2,3)=1
         MATRIX(2,4)=1
         CUB(1)=.42
         CUB(2)=.135
         VLB(1)=.008
         VLB(2)=.008
          VLB(3)=.008
         VLB(4)=.03
         KONTYP(1)=2
         KONTYP(2)=2
```

```
      VARTYP(1)=3
      VARTYP(2)=3
      VARTYP(3)=3
      VARTYP(4)=3
      VNAME(1)='DELTA1'
      VNAME(2)='DEL1'
      VNAME(3)='DEL2'
      VNAME(4)='DELTA3'
      NUMFNC=1
       NUMNLC=0
      NTOT=1
      X(1)=.11
      X(2)=.11
      X(3)=.11
      X(4)=.11
      EPSFES=.0001
      EPSHQ=1.E-9
      EPSZRO=.00001
      TAUMAX=1.
      CALL GPM
      STOP
      END
```

END OF COMPILATION: NO DIAGNOSTICS.

```
FNCL
(ASG 1.10S-01/24/74-16:27:43 (,0)        FNCL

UTINE FNCL        ENTRY POINT 000530

ACE USED:

   DATA    000107
   CODE    000543

RNAL REFERENCES:

   DLOG
   NERR3$

ACE ASSIGNMENT:

R 000063 A              D R 000064 B            D R 000062 BETA          D D 000014 D
D 000022 DELTA3         D D 000016 DEL1         D D 000020 DEL2          D D 000036 D
D 000034 DV11           D D 000040 DV121        D D 000052 DV122         D D 000056 D
D 000054 DV1T2          D D 000046 DV2T4        D D 000042 DV24          D   000104 D
D 000012 VAR            D D 000000 V1           D D 000004 V1T           D D 000010 V
D 000006 V2T            D D 000024 X1           D D 000026 X2            D D 000030 X
```

```
      SUBROUTINE FNCL(F,G,X,N)
      DOUBLE PRECISION F,G,X,V1,V2,V1T,V2T,V12,VAR
      DOUBLE PRECISION DELTA1,DEL1,DEL2,DELTA3
      DOUBLE PRECISION X1,X2,X3,X4,DV11,DV1T1,DV121,DV24,DV124,DV2T4,
     1DV1T2,DV122,DV2T3,DV123
      DIMENSION G(2),X(2)
      DELTA2=.03
      T=.015
      DELTA1=X(1)
      DEL1=X(2)
      DEL2=X(3)
       DELTA3=X(4)
       BETA=.5
      A=.0287
      B=-.0272
      X1=DEL1+DEL2+DELTA3+DELTA2+DELTA1
      X2=DEL1+DEL2+DELTA1+DELTA2
      X3=DEL1+DEL2+DELTA3+DELTA2
      X4=DEL1+DEL2+DELTA2
        V1=A+B*ALOG(DELTA1)-1.5*B
        V2=A+B*ALOG(DELTA3)-1.5*B
      V1T=A+B/DELTA1*((T+DEL1+DELTA1)*ALOG(T+DEL1+DELTA1)-(T+DEL1)*ALOG(
     1T+DEL1)-DELTA1)
      V2T=A+B/DELTA3*((DELTA2-T+DEL2+DELTA3)*ALOG(DELTA2-T+DEL2+DELTA3)-
     1(DELTA2-T+DEL2)*ALOG(DELTA2-T+DEL2)-DELTA3)
      V12=A+.5*B/DELTA1/DELTA3*(X1*X1*ALOG(X1)-X2*X2*ALOG(X2)-X3*X3*ALOG
     1(X3)+X4*X4*ALOG(X4)-3*DELTA1*DELTA3)
      VAR=1+(1-BETA)**2*V1+BETA**2*V2-2*(1-BETA)*V1T+2*BETA*(1-BETA)*
     1V12-2*BETA*V2T
```

```
      F=-VAR
      DV11=B/DELTA1
      DV1T1=B/DELTA1*(1-(T+DEL1)/DELTA1*ALOG(1+DELTA1/(T+DEL1)))
      DV1T2=B/DELTA1*ALOG(1+DELTA1/(T+DEL1))
      DV122=.5*B/DELTA1/DELTA3*(X1*(1+2*ALOG(X1))-X2*(1+2*ALOG(X2))-X3*(
     11+2*ALOG(X3))+X4*(1+2*ALOG(X4)))
      DV123=DV122
      DV2T3=B/DELTA3*ALOG(1+DELTA3/(DEL2+DELTA2-T))
      DV24=B/DELTA3
      DV2T4=B/DELTA3*(1-(DEL2+DELTA2-T)/DELTA3*ALOG(1+DELTA3/(DEL2+DELTA
     12-T)))
      DV124=.5*B/DELTA1/DELTA3*(X1*(1+(2*DELTA3-X1)/DELTA3*ALOG(X1))-X3*
     1(1+(2*DELTA3-X3)/DELTA3*ALOG(X3))+X2*X2*ALOG(X2)/DELTA3       -X4
     2*X4*ALOG(X4)/DELTA3)
      DV121=.5*B/DELTA1/DELTA3*(X1*(1+(2*DELTA1-X1)*ALOG(X1)/DELTA1)-X2
     1(1+(2*DELTA1-X2)*ALOG(X2)/DELTA1)  +X3*X3*ALOG(X3)/DELTA1-X4*X4*ALO
     2G(X4)/DELTA1)
      G(1)=(1-BETA)**2*DV11-2*(1-BETA)*DV1T1+2*BETA*(1-BETA)*DV121
      G(2)=-2*(1-BETA)*DV1T2+2*BETA*(1-BETA)*DV122
      G(3)=-2*BETA*DV2T3+2*BETA*(1-BETA)*DV123
      G(4)=BETA*BETA*DV24-2*BETA*DV2T4+2*BETA*(1-BETA)*DV124
      G(1)=-G(1)
      G(2)=-G(2)
      G(3)=-G(3)
      G(4)=-G(4)
      RETURN
      END
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ND OF COMPILATION: NO DIAGNOSTICS.

01/24/74 VERSION UWCC1.1

UNIVERSITY OF WISCONSIN COMPUTING CENTER - SUBROUTINE GPM

FINAL SOLUTION

TITLE - OPTIMUM SELECTION OF CALIBRATION TIMINGS FOR MINIMUM NOISE RADIANCE VARIANCE

ITERATION	5	FUNCTION VALUE	-.89521330+00	GRADIENT NORM	.82508291+00
DIRECTION NORM	.11243425-04	INITIAL STEPLENGTH	.13120257+00	PREVIOUS STEP	.30178946-05
NORM PROJECTED GRAD	-.41165917-05	CONJUGATE NORM	.41165916-05		
ERROR INDICATOR	0	FINAL TIME	214	CONSTRAINTS IN BASIS	3

CONSTRAINT DATA

NAME	TYP	ACT	BAS	VALUE	DUAL	IN GRAD	IN S	LOWER BND	UPPER BND	DIST TO LB	DIST TO UB
1	2	0	-1	.72722321-01	.00000000	-.11788+01	-.41166-05	-.10000+21	.42000+00	.10000+21	.34728+00
2	2	0	-1	.38000000-01	.00000000	-.58170+00	.00000	-.10000+21	.13500+00	.10000+21	.97000-01

VARIABLE DATA

NAME	TYP	ACT	BAS	VALUE	DUAL	IN GRAD	IN S	LOWER BND	UPPER BND	DIST TO LB	DIST TO UB
DELTA1	3	0	-1	.26722321-01	.00000000	-.41166-05	-.41166-05	.80000-02	.10000+21	.18723-01	.10000+21
DEL1	3	1	3	.30000000-02	-.59711543+00	-.59712+00	.00000	.30000-02	.10000+21	.17851-10	.10000+21
DEL2	3	1	1	.80000004-02	-.56920287+00	-.56920+00	.00000	.80000-02	.10000+21	.40615-09	.10000+21
DELTA3	3	1	2	.30000000-01	-.12439612-01	-.12440-01	.00000	.30000-01	.10000+21	.11154-09	.10000+21

COUNTS ON PROCEDURE CALLS

PROJECTIONS	30
ACCELERATIONS	13
INVERSIONS	1
CONSTRAINT ADDS	3
CONSTRAINT DROPS	0
STEPS	5
INTERPOLATIONS	1
STEP HALVINGS	2
FUNCTION COMPUTATIONS	13

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02/08/74

UNIVERSITY OF WISCONSIN COMPUTING CENTER - SUBROUTINE GPM

VERSION UWCC1.1

C(TAU) = .02277643 - .020603144 hr ( ) fmax = 26 KHz fmin = .026 Hz f_c = 750 Hz

FINAL SOLUTION
TITLE - OPTIMUM SELECTION OF CALIBRATION TIMINGS FOR MINIMUM NOISE RADIANCE VARIANCE

ITERATION	12	FUNCTION VALUE	-.91957559+00	GRADIENT NORM	.63341736+00
DIRECTION NORM	.20079017-04	INITIAL STEPLENGTH	.43298920-03	PREVIOUS STEP	.19660050-04
NORM PROJECTED GRAD	.30647672-05	CONJUGATE NORM	.10742792-05		
ERROR INDICATOR	0	FINAL TIME	343	CONSTRAINTS IN BASIS	2

CONSTRAINT DATA

NAME	TYP	ACT	BAS	VALUE	DUAL	IN GRAD	IN S	LOWER BND	UPPER BND	DIST TO LB	DIST TO UB
1	2	0	-1	.70055162-01	.00000000	-.89579+00	-.34708-06	-.10000+21	.42000+00	.10000+21	.34994+00
2	2	0	-1	.35028203-01	.00000000	-.44789+00	-.91308-06	-.10000+21	.13500+00	.10000+21	.99972-01

VARIABLE DATA

NAME	TYP	ACT	BAS	VALUE	DUAL	IN GRAD	IN S	LOWER BND	UPPER BND	DIST TO LB	DIST TO UB
DELTA1	3	0	-1	.27026959-01	.00000000	.14761-05	.56600-06	.80000-02	.10000+21	.19027-01	.10000+21
DEL1	3	1	2	.30000007-02	.44789786+00	-.44790+00	.00000	.80000-02	.10000+21	.66675-09	.10000+21
DEL2	3	1	1	.80000006-02	.44788956+00	-.44789+00	.00000	.80000-02	.10000+21	.59388-09	.10000+21
DELTA3	3	0	-1	.27028202-01	.00000000	-.26859-05	-.91308-06	.80000-02	.10000+21	.19028-01	.10000+21

COUNTS ON PROCEDURE CALLS

PROJECTIONS	33
ACCELERATIONS	28
INVERSIONS	2
CONSTRAINT ADDS	4
CONSTRAINT DROPS	0
STEPS	12
INTERPOLATIONS	1
STEP HALVINGS	0
FUNCTION COMPUTATIONS	28

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APPENDIX IV

Effect of averaging shutter calibration observations for 'n' lines on variance of noise equivalent radiance is discussed below

It has been proved in previous reports on the effect of calibration procedure on variance of noise radiance that:

$$\text{VARIANCE} = \alpha^2\{V_t + (1-\beta)^2 V_1 + \beta^2 V_2 - 2(1-\beta)V_{1t} + 2\beta(1-\beta)V_{12} - 2\beta V_{2t}\} \quad (1)$$

where the shutter calibration observations were average only for one line of data. The only modifications in this basic equation are as follows:

1) $V_2 = E\left\{\frac{1}{n}\sum_{i=1}^{n} \bar{e}_{300}\right\}^2$ where 'n' number of lines to be averaged

$$= \frac{1}{n^2}(\bar{e}_{300,1} + \bar{e}_{300,2} + \bar{e}_{300,3} + \ldots + \bar{e}_{300,n})^2$$

where $\bar{e}_{300,i}$ is average of shutter calibration readings of 'i'th line.

$$V_2' = \frac{1}{n^2}(\bar{e}^2_{300,1} + \bar{e}^2_{300,2} + \ldots + \bar{e}^2_{300,n})$$

$$+ 2\bar{e}_{300,1}(\bar{e}_{300,2} + \bar{e}_{300,3} + \ldots + \bar{e}_{300,n})$$

$$+ 2\bar{e}_{300,2}(\bar{e}_{300,3} + \bar{e}_{300,4} + \ldots + \bar{e}_{300,n})$$

.....

$$+ 2\bar{e}_{300,(n-2)}(\bar{e}_{300,(n-1)} + \bar{e}_{300,n})$$

$$+ 2\bar{e}_{300,(n-1)}\ \bar{e}_{300}\ \bar{e}_n$$

$$= \frac{1}{n^2}[n\ \bar{e}^2_{300,1} + 2(n-1)\ \bar{e}_{300,1}\ \bar{e}_{300,2} + 2(n-2)\bar{e}_{300,1}\ \bar{e}_{300,2} + \ldots$$

$$+ 2\ \bar{e}_{300,1}\ \bar{e}_{300,n}]$$

$$= \frac{\bar{e}^2_{300,1}}{n} + (0) = \frac{V_2}{n}$$

The time interval from one calibration event to another is .6 sec. Thus the correlation between one calibration event and another is zero to good approximation; so the second order correlations are ≈ 0.

2) $$V'_{12} = \frac{1}{n}\bar{e}_4(\bar{e}_{300,1} + \bar{e}_{300,2} + \dots + \bar{e}_{300,n})$$

$$= \frac{1}{n}\bar{e}_4\,\bar{e}_{300,1} + \emptyset = \frac{1}{n}V_{12}$$

Again the time interval between dc restore and second calibration is > 0.6 sec and hence second order correlations are ≈ 0.

$$\therefore\quad V'_{12} = \frac{1}{n}\bar{e}_4\,\bar{e}_{300,1} = \frac{1}{n}V_{12}$$

3) $$V'_{12} = \frac{1}{n}e_t\,(\bar{e}_{300,1} + \bar{e}_{300,2} + \dots + \bar{e}_{300,n})$$

$$= \frac{1}{n}e_t\,(\bar{e}_{300,1} + e_t\,\bar{e}_{300,2} + \dots + e_t\,\bar{e}_{300,n})$$

$$= \frac{1}{n}e_t\,\bar{e}_{300,1} + 0 = \frac{1}{n}V_{2t}$$

Again the time interval between earth observation and second calibration event is > 0.6 sec and hence subsequent correlations are ≈ 0.

Therefore the net effect on variance of noise radiance is:

$$\frac{VAR}{\sigma^2} = \alpha^2\left\{V_t + (1-\beta)^2V_1 + \beta^2\frac{V_2}{n} - 2(1-\beta)V_{1t} + 2\beta(1-\beta)\frac{V_{12}}{n} - 2\beta\frac{V_{2t}}{n}\right\}$$

$$= \alpha^2\; V_t + (1-\beta)^2V_1 - 2(1-\beta)V_{1t} + \frac{1}{n}\beta[\beta V_2 + 2(1-\beta)V_{12} - 2V_{2t}]$$

Let $CVAR = \beta\{\beta V_2 + 2(1-\beta)V_{12} - 2V_{2t}\}$. Then $\frac{1}{n}$ CVAR is that contribution to total variance (of a single sample) which depends on n. Since CVAR is negative (see Tables 3 and 6), and thus reduces the total variance, increasing the number of calibration events (n) which are averaged, increases the total variance beyond that obtained from line by line calibration.

TABLES

Tables for fmax = 26KHz, fmin = .026 Hz fc = 750 Hz

DELTA1 = .027 sec DEL1 = .008 sec DELTA2 = .03 sec DEL2 = .008 sec

DELTA3 = .03 sec

$C(\tau au) = .02277643 - .020603144 \ln(\tau)$

t = 0 @ left edge of image line

TABLE 1

t(sec)	V_1	V_2	V_{12}	V_{1t}	V_{2t}
0.0	.1281	.1259	.0765	.1036	.08357
0.0075	.1281	.1259	.0765	.0965	.08682
0.015	.1281	.1259	.0765	.09147	.09071
0.0225	.1281	.1259	.0765	.0875	.09558
0.03	.1281	.1259	.0765	.0841	.10219

TABLE 2

Variance of noise radiance/$\alpha^2\sigma^2$

t(sec) \ β	0.0	.25	0.5	0.75	1.0
0.0	0.9212	.93506	.94515	.95317	.95984
0.0075	0.9116	.92044	.92606	.92964	.93136
0.015	0.9148	.91843	.91959	.91873	.91545
0.0225	0.9304	.92904	.92574	.92044	.91219
0.03	0.9588	.95227	.94450	.93477	.92154

TABLE 3

CVAR contribution to variance of noise radiance by shutter calibration

t(sec) \ β	0.0	0.25	0.5	0.75	1.0
0.0	0.0	-.0052	-.0138	-.0258	-.0412
0.0075	0.0	-.0068	-.017	-.0307	-.0477
0.015	0.0	-.0878	-.0209	-.0365	-.0555
0.0225	0.0	-.0112	-.0258	-.0438	-.0652
0.03	0.0	-.0145	-.0324	-.0538	-.0785

Tables for fmax = 17450 Hz fmin = .026 Hz fc = 750 Hz

DELTA1 = .027 sec DEL1 = .008 sec DELTA2 = .03 sec DEL2 = .008 sec

DELTA3 = .03 sec

C(τau) = .0287 - .0272 ln τ

TABLE 4

t(sec)	V_1	V_2	V_{12}	V_{1t}	V_{2t}
0.0	.16774	.16488	.09968	.13519	.10897
0.0075	.16774	.16488	.09968	.12605	.11326
0.015	.16774	.16488	.09968	.11939	.11839
0.0225	.16774	.16488	.09968	.11410	.12482
0.03	.16774	.16488	.09968	.10970	.13355

TABLE 5

Variance of noise radiance/$\sigma^2\alpha^2$

t(sec) \ β	0.0	0.25	0.50	0.75	1.00
0.0	.89736	.88477	.88883	.90956	.94694
0.0075	.91564	.89633	.89368	.90769	.93836
0.015	.92896	.90376	.89521	.90333	.92810
0.0225	.93954	.90848	.89408	.89633	.91525
0.03	.94835	.91072	.88974	.88544	.89778

TABLE 6

Contribution of variance due to shutter calibration CVAR

t(sec) \ β	0.0	0.25	0.5	0.75	1.0
0.0	0.	-.0068	-.018	-.033	-.0531
0.0075	0.	-.0089	-.022	-.040	-.0616
0.0150	0.	-.0115	-.0273	-.047	-.0719
0.0225	0.	-.0147	-.034	-.057	-.085
0.0300	0.	-.019	-.042	-.070	-.10

NOTE: This contribution is negative and hence any effort to reduce this part is undesirable.

DELTA		DELTA2		DELTA3
space	DEL1	t_{earth}	DEL2	shutter

$$CVAR = \beta[\beta V_2 + 2(1-\beta)V_{12} - 2V_{2t}]$$