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SNPO-C Records

MASTER

REVISION 1
TO
RN-S-0469

To AEC-NASA Space Nuclear Propulsion Office

E-1 COMMON ANALOG MODEL (U)

NERVA Program Contract SNP-1

July 1969

GROUP-1
EXCLUDED FROM AUTOMATIC DOWNGRADING
AND DECLASSIFICATION
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ATOMIC ENERGY ACT OF 1954

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CONTENTS

MASTER

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ENCLOSURE 1

	Revision	Date
C. Controls, Actuators, and Safety Circuits		
1. Nuclear Subsystem Controls	1	5/15/69
2. Propellant Feed System Controls	1	5/15/69
3. Emergency System Controls	-	-
D. Support Facility	-	-
II. DERIVATIONS		
A. General	-	-
B. Specific	-	-
III. MODEL CHECKS		
A. Design		
1. Steady State	1	5/15/69
2. Frequency Response	1	5/15/69
3. Transient Response	-	-
B. Low Power		
1. Steady State	1	5/15/69
2. Frequency Response	1	5/15/69
3. Transient Response	-	-
IV. NOMENCLATURE	1	5/15/69

APPROVED:

D. Buden 5-15-69
D. Buden, AGC Date

ACKNOWLEDGED:

R. P. Rose 7/1/69
R. P. Rose, WANL Date

I A-2 TURBOPUMP

Pump inlet conditions at station 3, high speed turbine inlet conditions at station 285 and low speed turbine exit conditions at station 30 are common to two parallel turbopumps. One of these turbopumps is described below in equations 2 through 20. The second is described by adding a final subscript "a" to all quantities in these equations except those at the common points.

1. $P_3 = 30$ psia, $T_3 = 40^{\circ}R$

2. $W_P = W_4$

3. $P_4 = P_3 + N^2 f\left(\frac{W_P}{N}\right)$

4. $P_{45} = P_4 + N_H^2 f\left(\frac{W_P}{N_H}\right)$

5. $T_{45} = T_3 + .015\ P_{45}$

6. $M_P = -1.874\times10^{-6}N^2 + 1.021\times10^{-3}W_P N - .0590W_P^2 \qquad \frac{W_P}{N} \geq .00626$

   $= 2.27\times10^{-6}N^2 \qquad \frac{W_P}{N} < .00626$

   Stall occurs at $\frac{W_P}{N} = .00518$

7. $M_{PH} = .3479\times10^{-6}N_H^2 + .4959\times10^{-3}W_P N_H - .04155W_P^2 \qquad \frac{W_P}{N_H} \geq .0009194$

   $= .7463\times10^{-6}N_H^2 \qquad \frac{W_P}{N_H} < .0009194$

   Stall occurs at $\frac{W_P}{N_H} = .0009194$

8. $\frac{dR_{29}}{dt} = 11.0\ (W_{TH} - W_T)$

9. $T_{29} = T_{27}\left\{1 - ET_H\left[1 - \left(\frac{P_{29}}{P_{285}}\right)^{.286}\right]\right\}$

10. $\frac{dP_{29}}{dt} = -1000\ (P_{29} - 5.32R_{29}T_{29})$

11. $C_{OH} = 415.6(T_{27})^{\frac{1}{2}}\left[1 - \left(\frac{P_{29}}{P_{285}}\right)^{.286}\right]^{\frac{1}{2}}$

I A-2 TURBOPUMP

12. $$\frac{u_H}{C_{OH}} = .04333 \frac{N_H}{C_{OH}}$$

13. $$ET_H = f\left(\frac{u_H}{C_{OH}}\right)$$

14. $$W_{TH} = \frac{P_{285}}{\sqrt{T_{27}}} f\left(\frac{P_{285}}{P_{29}}\right)$$

15. $$M_{TH} = W_{TH} (.04364\ C_{OH} - .003793\ N_H)$$

16. $$C_O = 415.6(T_{29})^{\frac{1}{2}} \left[1 - \left(\frac{P_{30}}{P_{29}}\right)^{.286}\right]^{\frac{1}{2}}$$

17. $$W_T = \frac{P_{29}}{\sqrt{T_{29}}} f\left(\frac{P_{29}}{P_{30}}\right)$$

18. $$M_T = W_T (.01729\ C'_O - .001435\ N)$$

19. $$\frac{dN_H}{dt} = 73.22 (M_{TH} - M_{PH})$$

20. $$\frac{dN}{dt} = 114.6 (M_T - M_P)$$

I A-2 TURBOPUMP

TABLE I A-2-1

$\frac{W_P}{N}$	$f\left(\frac{W_P}{N}\right)$
0.000×10^{-3}	$.7166 \times 10^{-6}$
2.934	.5972
4.891	.5524
6.847	.5345
7.825	.5196
8.803	.4957
9.292	.4807
10.27	.4389
10.96	.3762
11.74	.2359

I A-2 TURBOPUMP

TABLE I A-2-2

$\frac{W_P}{N_H}$	$f\left(\frac{W_P}{N_H}\right)$
0.000×10^{-3}	1.311×10^{-6}
.9194	1.320
.9194	1.383
1.272	1.359
1.712	1.299
2.299	1.191
2.788	1.069
3.423	0.860
3.912	0.660
4.842	0.000

I A-2 TURBOPUMP

TABLE I A-2-3

$\frac{u_H}{C_{OH}}$	$f\left(\frac{u_H}{C_{OH}}\right)$
0	0
.04	.240
.08	.455
.12	.620
.14	.681
.16	.732
.18	.763
.20	.779
.22	.765
.26	.723

I A-2 TURBOPUMP

TABLE I A-2-4

P_{285}/P_{29}	$f(P_{285}/P_{29})$
1.0	0
1.1	.160
1.2	.210
1.4	.267
1.6	.299
2.0	.331
2.5	.353
3.0	.365
5.0	.380
8.0	.383

I A-2 TURBOPUMP

TABLE I A-2-5

P_{29}/P_{30}	$f(P_{29}/P_{30})$
1.0	0
1.06	.88
1.14	1.33
1.24	1.71
1.34	1.97
1.50	2.26
1.70	2.49
2.0	2.66
2.2	2.69
2.4	2.70

I A-3 PUMP DISCHARGE LINE

1. $$\frac{dW_4}{dt} = 65.8\ (P_{45} - P_{19}) - .283\ W_4\ |W_4| \qquad W_4 \geq 0$$

2. $$\frac{dW_{4a}}{dt} = 65.8\ (P_{45a} - P_{19}) - .283 W_{4a}\ |W_{4a}| \qquad W_{4a} \geq 0$$

3. $$\frac{dP_{19}}{dt} = \frac{1810 + 1.4P_{19}}{13.26}\ (W_4 + W_{4a} - W_{SSI} - W_{SSB} - W_5)$$

4. $$T_{19} = T_{45}$$

I A-4 TURBINE EXHAUST LINE

1. $P_{30} = 5.32 R_{30} T_{30}$

2. $\frac{dR_{30}}{dt} = \frac{1}{3.4844} (W_T + W_{TA} - W_{31})$

3. $W_{31} = 40.5 \sqrt{\frac{R_{30} + R_{32}}{2} (P_{30} - P_{32})}$

4. $T_{30} = T_{29}$

5. $T_{31} = T_{30}$

I B-1 SUPPORT SYSTEM CONNECTION TO NOZZLE TORUS

1. P_{19} See Section IA-3 Eq. 3

2. T_{19} See Section IA-3 Eq. 4

3. $T_5 = T_{19}$

4. $$\frac{dW_5}{dt} = 60.9\ (P_{19} - P_5) - .201\ W_5 \left| W_5 \right|$$

5. $$\frac{dP_5}{dt} = \frac{1810+1.4P_5}{4.37}\ (W_5 - W_{NC})$$

1 B-2 NOZZLE SKIRT/SIMULATOR COOLANT TUBES

1. $$\frac{dT_{SKC}}{dt} = .0347\left(.296\left|W_{NC}\right|^{.8}(\varphi_{SK} - T_{SKC}) - 3.79W_{NC}(T_{SKC}-T_5)\right)$$

2. $$\frac{dH_{SK}}{dt} = .00337\left(.0576\left|W_N\right|^{.8}(T_{15}-\varphi_{SK}) - .296\left|W_{NC}\right|^{.8}\left((\varphi_{SK}-T_{SKC})\right)\right)$$

3. $$\varphi_{SK} = 6.55H_{SK} + 35$$

I B-3 NOZZLE COOLANT TUBES

1. $$\frac{dT_{NC}}{dt} = .2510\left(.8200\left|W_{NC}\right|^{.8}(\varphi_N - T_{NC}) - 3.840W_{NC}(T_{NC}-T_{SKC})\right)$$

2. $$\frac{dH_N}{dt} = .001039\left(.3070\left|W_N\right|^{.8}(T_{15} - \varphi_N) - .8200\left|W_{NC}\right|^{.8}(\varphi_N - T_{NC})\right)$$

3. $$\varphi_N = 3.230H_N + 870.0$$

4. $$\frac{dW_{NC}}{dt} = 99.80\left(P_5 - P_7 - \frac{.02732}{R_7}\left|W_{NC}\right| W_{NC}\right)$$

I B-4 REFLECTOR INLET PLENUM

1. $\frac{dR_7}{dt} = .2919\ (W_{NC} - W_R - W_{DB})$

2. $\frac{dT_7}{dt} = \frac{.2919}{R_7}\ (W_{NC}T_{NC} - W_R T_7 - W_{DB}T_7)$

3. $P_7 = T_7 f_1(R_7) - f_2(R_7)$

4. $T_{7\ min} = 52. + .043\ P_7$ $\qquad P_7 < 210$ psia

I B-4 REFLECTOR INLET PLENUM

TABLE I B-4-1

R_7 (lb/ft^3)	$f_1(R_7)$ (psia/°R)
0.0000	0.000
0.2516	1.426
0.6290	3.881
0.8806	5.733
1.132	7.787
1.635	12.53
2.020	16.62
2.520	23.20
3.019	31.87
3.271	37.15
3.744	49.82

I B-4 REFLECTOR INLET PLENUM

TABLE I B-4-2

R_7 (lb/ft^3)	$f_2(R_7)$ (psia)
0.0000	0.0
0.2516	15.63
0.5032	60.06
1.040	224.2
1.384	410.7
1.824	674.7
2.390	1089.0
2.768	1420.0
3.500	2160.0
3.744	2371.0

I B-5 REFLECTOR AND PERIPHERAL SHIELD

1) $\frac{d}{dt} H_r = .0002509\left(1.774 \left| W_r \right| (T_7 - \phi_r) + 159.0\, S_{NQ}\right)$

2) $\phi_r = f(H_r)$ (See Table I B-5-1)

3) $T_9 = .6419\, \phi_r - (.6419 - 1)\, T_7$

4) $W_r = 12.04\left(R_{10} \left| P_7 - P_{10} \right|\right)^{.5} \left[\frac{(P_7 - P_{10})}{\left| P_7 - P_{10} \right|}\right]$

I B-5 REFLECTOR AND PERIPHERAL SHIELD (continued)

TABLE I B-5-1

ϕ_r vs H_r

H_r (BTU/lb.)	ϕ_r (°R)
0	0
5	185
10	235
15	275
20	310
25	335
30	360
35	385
40	405
45	425
50	445
55	465
60	480
100	605

I B-6 DOME END PLENUM

1) $\frac{d}{dt} R_{10} = .04824 (W_r + W_{ss} + W_{ssb} - W_c)$

2) $\frac{d}{dt} T_{10} = .09648 (W_r T_9 + W_{ss} T_{22} + W_{ssb} T_{19} - W_c T_{10})$

3) $P_{10} = 5.32 R_{10} T_{10}$

I B-9 CORE AND CORE PERIPHERY

1) $\frac{d}{dt} H_{c1} = .0009772\left(3.699\left|W_c\right| (T_{10} - \phi_{c1}) + 3995.S\right)$

2) $\phi_{c1} = f(H_{c1})$ (See Table I B-9-1)

3) $T_{c1e} = 1.057\phi_{c1} - (1.057 - 1) T_{10}$

4) $\frac{d}{dt} H_{c2} = .0009772\left(4.362\left|W_c\right| (T_{c1e} - \phi_{c2}) + 6518.S\right)$

5) $\phi_{c2} = f(H_{c2})$ (See Table I B-9-1)

6) $T_{c2e} = 1.176\,\phi_{c2} - (1.176 - 1) T_{c1e}$

I B-9 CORE AND CORE PERIPHERY (continued)

7) $\frac{d}{dt} H_{c3} = .0009772 \left(4.052 \left| W_c \right| (T_{c2e} - \phi_{c3}) + 3740.S\right)$

8) $\phi_{c3} = f(H_{c3})$ (See Table I B-9-1)

9) $T_{15} = \left(.8926\phi_{c3} - (.8926 - 1) T_{c2e}\right) .9918$

10) $\phi_c = .125 (3\phi_{c1} + 2\phi_{c2} + 3\phi_{c3})$

11) $R_c = .159 R_{10} + .841 R_{15}$

12) $W_c = \left[\frac{\left| P_{10} - P_{15} \right|}{\frac{.005951}{R_{10}} + \frac{1.906 \times 10^{-4}}{R_{15}}}\right]^{.5} \cdot \left[\frac{(P_{10} - P_{15})}{\left|P_{10} - P_{15}\right|}\right]$

I B-9 CORE AND CORE PERIPHERY (continued)

TABLE I B-9-1

ϕ_{cn} vs H_{cn} n = 1, 2, 3

H_{cn} (BTU/lb.)	ϕ_{cn} (^{o}R)
0.	0.
200.	1110.
400.	1630.
600.	2085.
800.	2530.
1000.	2950.
1200.	3350.
1400.	3760.
1600.	4170.
1800.	4580.
2000.	4990.
2200.	5400.
2400.	5810.

1 B-10 THRUST CHAMBER

1. $\frac{dR_{15}}{dt} = .04346(W_C - W_N - W_{HB})$

2. $P_{15} = 5.32R_{15}\ T_{15}$

3. $W_N = \left[\frac{12.99P_{15}}{T_{15}^{.5}}\right]$

4. $\frac{dT_{15M}}{dt} = \frac{W_N^{.5}}{2.85}\ (T_{15} - T_{15M})$

IB-11 TURBINE INLET LINE

1. $W_{27} = 3.96 \sqrt{R_{27}(P_{15} - P_{27})}$

2. $W_{DB} = .2045 \sqrt{R_7(P_7 - P_{15})}$

3. $W_{HB} = W_{27} - W_{DB}$

4. $P_{27} = 5.32\ R_{27}\ T_{27}$

5. $\frac{dR_{27}}{dt} = \frac{1}{1.215}\ (W_{27} - W_V - W_{Va})$

6. $\frac{dT_{27}}{dt} = \frac{1}{1.215\ R_{27}} \left[W_{HB}(T_{15}-T_{27}) - W_{DB}(T_{27}-T_7)\right]$

7. $W_V = 4f(\theta_V) \left[\frac{1}{2}(R_{27} + R_{285})(P_{27} - P_{285})\right]^{\frac{1}{2}}$

8. $W_{Va} = 4f(\theta_{Va}) \left[\frac{1}{2}(R_{27} + R_{285})(P_{27} - P_{285})\right]^{\frac{1}{2}}$

9. $\frac{dR_{285}}{dt} = \frac{1}{.1636}\ (W_V + W_{Va} - W_{TH} - W_{THa})$

10. $P_{285} = 5.32\ R_{285}\ T_{27}$

I- B-11 TURBINE INLET LINE

TABLE I B-11-1

θ_V, θ_{Va}	$f(\theta_V)$, $f(\theta_{Va})$
0	.00372
10	.01607
20	.03453
25	.1064
30	.1765
35	.2649
40	.3784
45	.5021
50	.6170
55	.7196
60	.7914
65	.8470
70	.8871
75	.9058
80	.9078
85	.8951
90	.8700

I B-12 SUPPORT SYSTEM INLET AND BYPASS

1) θ_{ssv} = Independent variable

2) $F_{ssv} = f(\theta_{ssv})$ (See Table I B-12-1)

3) $$W_{ssi} = 3.472\, F_{ssv} \left| P_{19} - P_{20} \right|^{.5} \left[\frac{(P_{19} - P_{20})}{\left| P_{19} - P_{20} \right|} \right]$$

4) $F_{ssb} = f(\theta_{ssv})$ (See Table I B-12-2)

5) $$W_{ssb} = .9343\, F_{ssb} \left| P_{19} - P_{10} \right|^{.5} \left[\frac{(P_{19} - P_{10})}{\left| P_{19} - P_{10} \right|} \right]$$

6) $$\frac{d}{dt} P_{20} = 985.6\, (W_{ssi} - W_{ss})$$

I B-12SUPPORT SYSTEM INLET AND BYPASS (continued)

TABLE I B-12-1

F_{ssv} vs θ_{ssv}

θ_{ssv} (Deg.)	F_{ssv}
0.0	0.13013
7.0787	0.15335
17.191	0.18975
27.303	0.23095
37.416	0.27868
47.528	0.33580
57.640	0.40747
67.753	0.50332
77.865	0.64650
87.978	0.91153
90.000	1.00000

I B-12 SUPPORT SYSTEM INLET AND BYPASS (continued)

TABLE I B-12-2

F_{ssb} vs θ_{ssv}

θ_{ssv} (Deg.)	F_{ssb}
0.0	1.0000
7.0787	0.9552
17.191	0.8913
27.303	0.8275
37.416	0.7637
47.528	0.6999
57.640	0.6362
67.753	0.5728
77.865	0.5089
87.978	0.4453
90.00	0.4325

I B-13 SUPPORT SYSTEM

1) $T_{20} = T_{19}$

2) $T_{ss1} = T_{20} + \left[\frac{.5837}{1 + 1.351|W_{ss}|}\right] (T_{ss4} - T_{ss1})$

3) $T_{ss1e} = 2\ T_{ss1} - T_{20}$

4) $T_{ss2} = T_{ss1e} + 1.895\ (\phi_{t2i} - T_{ss2})$

5) $T_{ss2e} = 2\ T_{ss2} - T_{ss1e}$

6) $T_{ss3} = T_{ss2e} + 9.390\ (\phi_{t2o} - T_{ss3}) + 2.066\ (\phi_{t3i} - T_{ss3})$

7) $T_{ss3e} = 1.3\ T_{ss3} - .3\ T_{ss2e}$

8) $T_{ss4} = T_{ss3e} + \left[\frac{.5857}{1 + 1.351|W_{ss}|}\right] (T_{ss1} - T_{ss4})$

9) $T_{22} = 2\ T_{ss4} - T_{ss3e}$

I B-13 SUPPORT SYSTEM (continued)

10) $$\phi_{t2_i} = \phi_{t2} + 1.054 \left| W_{ss} \right| (T_{ss2} - \phi_{t2_i})$$

11) $$\phi_{t2_o} = \phi_{t2} + .05321 \left| W_{ss} \right| (T_{ss3} - \phi_{t2_o})$$

12) $$\phi_{t3_i} = \phi_{t3} + .02171 \left| W_{ss} \right| (T_{ss3} - \phi_{t3_i})$$

13) $$\frac{d}{dt}\phi_{t2} = 38.62 (\phi_{t2_o} - \phi_{t2}) - .6024 (\phi_{t2} - \phi_{t2_i}) + 2.419 S_{NQ}$$

14) $$\frac{d}{dt}\phi_{t3} = 1.157 (\phi_p - \phi_{t3}) - 57.04 (\phi_{t3} - \phi_{t3_i}) + 2.123 S_{NQ}$$

I B-13 SUPPORT SYSTEM (continued)

15) $\frac{d}{dt}\phi_p = .3089\ (\phi_{sg} - \phi_p) - .3312\ (\phi_p - \phi_{t3}) + 1.087 S_{NQ}$

16) $\frac{d}{dt}\phi_{sg} = 1.930\ (\phi_{c2} - \phi_{sg}) - .08184(\phi_{sg} - \phi_p) + .9786\ S_{NQ}$

17) $P_{ss2} = P_{20} - .02005(P_{20} - P_{10})$

18) $R_{ss2} = \left[\frac{P_{ss2}}{5.32\ T_{ss2}}\right]$

19) $P_{ss2e} = P_{20} - .5355\ (P_{20} - P_{10})$

20) $R_{ss2e} = \left[\frac{P_{ss2e}}{5.32\ T_{ss2e}}\right]$

21) $R_{ss} = .7913\ R_{ss2} + (1 - .7913)\ .4650\ R_{ss2e}$

22) $W_{ss} = .8836\ \left(R_{ss2e}\left|P_{20} - P_{10}\right|\right)^{.5}\left[\frac{(P_{20} - P_{10})}{|P_{20} - P_{10}|}\right]$

1 B-14 REACTIVITY

1) $$Dk_f = 21.31 R_c + 1.973 R_{ss} - 8.0 \times 10^{-4} (\phi_c - 520.0)$$

2) $$Dk_d = 6.900 \sin^2\left(\frac{\theta_{D_M}}{2}\right) - 4.687$$

3) $$Dk_t = Dk_f + Dk_d$$

I B-15 KINETICS

1) $\frac{d}{dt} S_N = 295.8\ (Dk_t - 1)\ S_N + .0276\ CI_1 + .235\ CI_2 + 1.65\ CI_3$

2) $\frac{d}{dt} CI_1 = 81.07\ S_N - .0276\ CI_1$

3) $\frac{d}{dt} CI_2 = 165.32\ S_N - .235\ CI_2$

4) $\frac{d}{dt} CI_3 = 49.41\ S_N - 1.650\ CI_3$

5) $\frac{d}{dt} Q = .00635\ (.06839\ S_N - Q)$

6) $S_{NQ} = 6.409\ Q + .6301\ S_N$

7) $S = Q + S_N$

I B-16 SKIRT EXTENSION

1. $P_{32} = 5.32\, R_{32}\, T_{32}$

2. $\frac{dR_{32}}{dt} = \frac{1}{2.3148}(W_{31} - W_{32})$

3. $T_{32} = T_{31}$

4. $W_{32} = 6.26 \frac{P_{32}}{\sqrt{T_{32}}}$

I C-1 NUCLEAR SUBSYSTEM CONTROLS

1) T_{15D} = Independent variable

2) $T_{15E} = T_{15D} - T_{15M}$

3) $$\frac{\theta D_M}{\theta D_D} = \frac{1}{1 + 0.16s + 0.025s^2}$$

4) $\theta D_D = \theta D_{D1} + \theta D_{D2} + \theta D_{D3}$

5) $T_{15EC} = T_{15E}$ for $|T_{15E}| < 180$

$= 180$ for $T_{15E} \geq 180$

$= -180$ for $T_{15E} \leq -180$

6) $$\frac{\theta D_{D1}}{T_{15EC}} = \frac{0.1\ (1 + 1.25s)\ (1 + 0.3s)}{(1 + 5.0s)(1 + 0.02s)}$$

I C-1 NUCLEAR SUBSYSTEM CONTROLS (continued)

7) $\dfrac{\theta D_{D2}}{T_{15EC}} = \dfrac{1.0 \cdot 10^{-4}}{s}$

8) $\dfrac{d}{dt}\ \theta D_{D3}$

$= 0$ for $|T_{15EC}| < 100$

$= 2$ for $T_{15EC} \geq 100$

$= -2$ for $T_{15EC} \leq -100$ and $T_{15M} < 4500$

$= -7$ for $T_{15EC} \leq -100$ and $T_{15M} \geq 4500$

I C-2 PROPELLANT FEEDSYSTEM CONTROLS

1. $P_{15E} = P_{15D} - P_{15}$

2. $\frac{\theta_{VD}}{P_{15E}} = \frac{.05623\ (1 + 10S)(1 + .5555S)}{S\ (1 + 1.5873S)(1 + .01S)}$

3. $\frac{\theta_V}{\theta_{VD}} = \frac{\theta_{Va}}{\theta_{VD}} = \frac{1}{1.75 \times 10^{-4}S^2 + 1.3 \times 10^{-2}S + 1}$

$0 < \theta_V,\ \theta_{VA} < 90^\circ$

$-450 < \dot{\theta}_V,\ \dot{\theta}_{Va} < 450^\circ/\text{sec}$

STEADY STATE VARIABLES (Y(I))

CI1	2.810D 05	CI2	6.771D 04	CI3	2.865D 03	HC1	3.759D 02
HC2	1.220D 03	HC3	1.897D 03	HN	2.189D 02	HR	2.754D 01
HSK	1.396D 02		0.0	P5	9.143D 02	P19	9.348D 02
P20	8.573D 02	P25	3.502D 01	P29A	3.502D 01	PHP	2.187D 03
PHSG	3.391D 03	PHT2	5.483D 02	PHT3	7.231D 02		0.0
Q	6.543D 00	R7	-6.345D-01	P10	-3.999D-01	R15	1.829D-02
R27	4.360D-02	R285	2.402D-02	R285A	2.413D-02	R29	5.115D-03
R29A	5.115D-03	R30	3.720D-03	R32	3.322D-03	RPM	7.550D 03
RPMA	7.550D 03	RPMH	2.609D 04	RPMHA	2.609D 04	SN	9.568D 01
T7	2.085D 02	T1C	3.022D 02	T15M	4.450D 03	T27	1.661D 03
		TSKC	8.298D 01		9.051D 01	THD	9.051D 01
TNC	2.085D 02		0.0	THDD2	0.0	THDD3	0.0
	9.051D 01	TPSSV	4.753D 01		3.001D 01	THV	3.001D 01
	4.571D 01	THVA	3.001D 01		3.001D 01		3.001D 01
	3.001D 01	W4	4.496D 01	W4A	4.496D 01		0.0
THVD	3.001D 01	WNC	6.848D 01		0.0	CT27	2.945D-01
W5	6.878D 01						

CO	4.398D 03	COA	4.398D 03	COH	1.075D 04	COHA	1.075D 04
DKD	-1.206D 00	DKF	1.206D 00	DKT	-5.651D-07	ETH	5.588D-01
ETHA	5.588D-01	P3	3.000D 01	P3A	3.000D 01	P4	6.093D 01
P4A	5.093D 01	P45	9.435D 02	P45A	9.435D 02		0.0
	0.0		0.0		0.0	P7	7.174D 02
P10	6.427D 02	P15	4.500D 02	P15D	4.500D 02	P15E	1.270D-09
P27	4.293D 02	P285	2.122D 02	P285A	2.122D 02	P30	2.547D 01
P31	0.0	P32	2.275D 01	PSS2	8.530D 02	PSS2E	7.424D 02
PHC	3.228D 03	PHC1	1.567D 03	PHC2	3.390D 03		0.0
	0.0		0.0	PHC3	4.779D 03	PHN	1.577D 03
PHR	3.477D 02	PHSK	9.425D 02	PHT2J	1.924D 02	PHT2PH	5.475D 02
PHT3J	6.957D 02	RC	7.895D-02	RSS	8.354D-01	RSS2	1.005D 00
RSS2E	6.290D-01	S	1.022D 02	SNQ	1.022D 02	T3	4.000D 01
T45	5.415D 01	T45A	5.415D 01		0.0		0.0
T5	5.415D 01	T9	2.979D 02	T15	4.625D 03	T15D	4.625D 03
T15E	0.0	T20	5.415D 01	T22	6.001D 02	T29	1.287D 03
T29A	1.287D 03	T30	1.287D 03	T31	1.287D 03	T32	1.287D 03
TC1E	1.640D 03	TC2E	3.698D 03	TSS1	7.566D 01	TSS1E	9.717D 01
TSS2	1.595D 02	TSS2E	2.218D 02	TSS3	5.459D 02	TSS3E	6.432D 02
TSS4	6.216D 02		0.0		0.0	TRQP	1.294D 02
TRQPA	1.294D 02	TRQPH	7.344D 02	TRQPHA	7.344D 02	TRQT	1.294D 02
TRQTA	1.294D 02	TRQTH	7.344D 02	TRQTHA	7.344D 02	THDD	9.051D 01
THDD1	0.0	THSSVD	4.753D 01	UCOH	1.052D-01		0.0
UCOHA	1.052D-01	W27	3.969D 00	W31	3.969D 00	W32	3.959D 00
WC	8.726D 01	WDB	2.664D 00	WHB	1.305D 00	WN	8.595D 01
WP	4.496D 01	WPA	4.496D 01	WR	6.581D 01	WSS	1.027D 01
WSSB	1.118D 01	WSSI	1.027D 01	WT	1.985D 00	WTA	1.985D 00
	0.0	WTH	1.985D 00				
WV	1.985D 00	WVA	1.985D 00				

(RAD./SEC.)	$\frac{\Delta T_{15}}{\Delta\theta_v}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta T_{15}}{\Delta\theta_{-}}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta T_{15}}{\Delta\theta_{ssv}}$ MAGNITUDE	DECIBELS	PHASE
1.000D-03	3.796D 03	71.585	0.001	3.218D 02	50.152	0.001	1.312D 02	42.359	0.001
2.500D-03	4.128D 03	72.313	18.102	3.458D 02	50.775	16.735	1.410D 02	42.984	16.614
3.950D-03	4.505D 03	73.263	26.378	3.807D 02	51.610	24.681	1.552D 02	43.820	24.484
6.280D-03	5.757D 03	75.203	35.213	4.664D 02	53.375	33.651	1.903D 02	45.587	33.325
1.000D-02	8.514D 03	78.602	39.199	6.765D 02	56.606	38.505	2.760D 02	48.819	38.062
1.570D-02	1.447D 04	83.185	25.798	1.136D 03	61.110	6.821	4.637D 02	53.323	25.945
2.500D-02	1.774D 04	84.978	-16.997	1.402D 03	62.933	-3.984	5.717D 02	55.143	-15.395
3.950D-02	1.328D 04	82.461	-50.209	1.062D 03	50.520	-45.054	4.325D 02	52.720	-47.291
6.280D-02	8.527D 03	78.615	-78.343	6.942D 02	56.829	-70.520	2.820D 02	49.004	-74.080
1.000D-01	4.399D 03	72.866	-95.454	3.679D 02	51.314	-83.951	1.483D 02	43.421	-89.589
1.570D-01	2.404D 03	67.618	-99.694	2.098D 02	46.435	-83.356	8.297D 01	38.378	-91.965
2.500D-01	1.439D 03	63.163	-102.426	1.345D 02	42.573	-79.605	5.098D 01	34.147	-92.302
3.950D-01	8.956D 02	59.041	-109.472	9.237D 01	39.310	-78.445	3.242D 01	30.217	-95.732
6.280D-01	5.239D 02	54.384	-121.244	6.269D 01	35.944	-79.535	1.953D 01	25.816	-101.076
1.000D 00	2.770D 02	48.851	-135.897	4.168D 01	32.399	-81.277	1.110D 01	20.908	-105.550
1.570D 00	1.335D 02	42.510	-150.364	2.767D 01	28.841	-83.000	6.206D 00	15.857	-107.265
2.500D 00	5.724D 01	35.154	-163.217	1.800D 01	25.104	-84.862	3.438D 00	10.727	-105.782
3.950D 00	2.349D 01	27.416	-173.259	1.164D 01	21.316	-86.906	2.010D 00	6.063	-102.686
6.280D 00	9.277D 00	19.348	-181.319	7.382D 00	17.363	-88.772	1.225D 00	1.765	-100.279
1.000D 01	3.654D 00	11.256	-189.037	4.647D 00	13.344	-90.410	7.665D-01	-2.310	-100.286
1.570D 01	1.480D 00	5.000	-198.686	2.961D 00	9.427	-92.063	4.878D-01	-6.236	-103.094
2.500D 01	5.785D-01	5.000	-213.129	1.856D 00	5.372	-94.215	3.019D-01	-10.403	-109.172
3.950D 01	2.201D-01	5.000	-233.106	1.169D 00	1.356	-97.218	1.827D-01	-14.766	-118.862
6.280D 01	7.799D-02	5.000	-259.749	7.257D-01	-2.784	-101.752	1.036D-01	-19.695	-133.111
1.000D 02	2.518D-02	5.000	69.540	4.414D-01	-7.103	-108.554	5.307D-02	-25.000	-151.880

(RAD./SEC.)	$\frac{\Delta P_{15}}{\Delta\theta_V}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta P_{15}}{\Delta\theta_d}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta P_{15}}{\Delta\theta_{SSV}}$ MAGNITUDE	DECIBELS	PHASE
1.000D-03	4.308D 02	52.685	0.001	3.152D 01	29.971	0.001	1.288D 01	22.199	0.001
2.500D-03	4.634D 02	53.319	16.916	3.408D 01	30.650	17.909	1.393D 01	22.877	17.747
3.950D-03	5.109D 02	54.167	24.925	3.780D 01	31.549	26.300	1.544D 01	23.774	26.050
6.280D-03	6.277D 02	55.954	33.929	4.686D 01	33.417	35.637	1.914D 01	25.639	35.253
1.000D-02	9.138D 02	59.216	38.839	6.891D 01	36.765	40.739	2.814D 01	28.985	40.151
1.570D-02	1.541D 03	63.757	26.897	1.171D 02	41.373	28.992	4.781D 01	33.590	28.094
2.500D-02	1.911D 03	65.623	-14.271	1.463D 02	43.303	-11.686	5.968D 01	35.517	-13.098
3.950D-02	1.454D 03	63.249	-46.022	1.128D 02	41.044	-42.578	4.597D 01	33.250	-44.800
6.280D-02	9.525D 02	59.577	-72.636	7.587D 01	37.601	-68.295	3.085D 01	29.785	-71.814
1.000D-01	5.031D 02	54.033	-87.883	4.162D 01	32.386	-83.257	1.681D 01	24.513	-88.809
1.570D-01	2.823D 02	49.012	-89.927	2.428D 01	27.705	-85.713	9.663D 00	19.702	-94.224
2.500D-01	1.723D 02	44.727	-89.712	1.560D 01	23.853	-86.405	6.000D 00	15.563	-99.171
3.950D-01	1.066D 02	40.555	-91.459	1.049D 01	20.412	-90.991	3.788D 00	11.568	-108.932
6.280D-01	6.116D 01	35.729	-90.697	6.693D 00	16.512	-99.792	2.199D 00	6.846	-123.614
1.000D 00	3.701D 01	31.366	-80.473	3.883D 00	11.782	-110.678	1.128D 00	1.049	-141.618
1.570D 00	2.887D 01	29.207	-72.752	2.048D 00	6.228	-119.636	5.036D-01	-5.959	-161.299
2.500D 00	2.273D 01	27.132	-77.689	9.953D-01	-0.041	-123.023	1.701D-01	-15.384	-185.920
3.950D 00	1.623D 01	24.205	-88.079	5.005D-01	-6.010	-121.174	3.515D-02	-29.082	-251.051
6.280D 00	1.072D 01	20.607	-100.844	2.628D-01	-11.606	-116.880	5.100D-02	-25.849	5.470
1.000D 01	6.748D 00	16.583	-116.313	1.450D-01	-16.773	-112.211	6.849D-02	-23.288	-23.050
1.570D 01	4.156D 00	12.373	-134.991	8.385D-02	-21.529	-108.700	7.270D-02	-22.768	-46.960
2.500D 01	2.448D 00	7.776	-158.858	4.734D-02	-26.495	-105.735	7.026D-02	-23.065	-77.101
3.950D 01	1.418D 00	3.033	-185.690	2.649D-02	-31.539	-100.152	6.299D-02	-24.014	-113.999
6.280D 01	7.979D-01	-2.004	-211.565	1.582D-02	-35.000	-88.672	5.190D-02	-25.697	-156.386
1.000D 02	4.310D-01	-7.311	-229.186	1.148D-02	-35.000	-78.176	3.799D-02	-28.406	-199.278

Both turbine power control valves are moved

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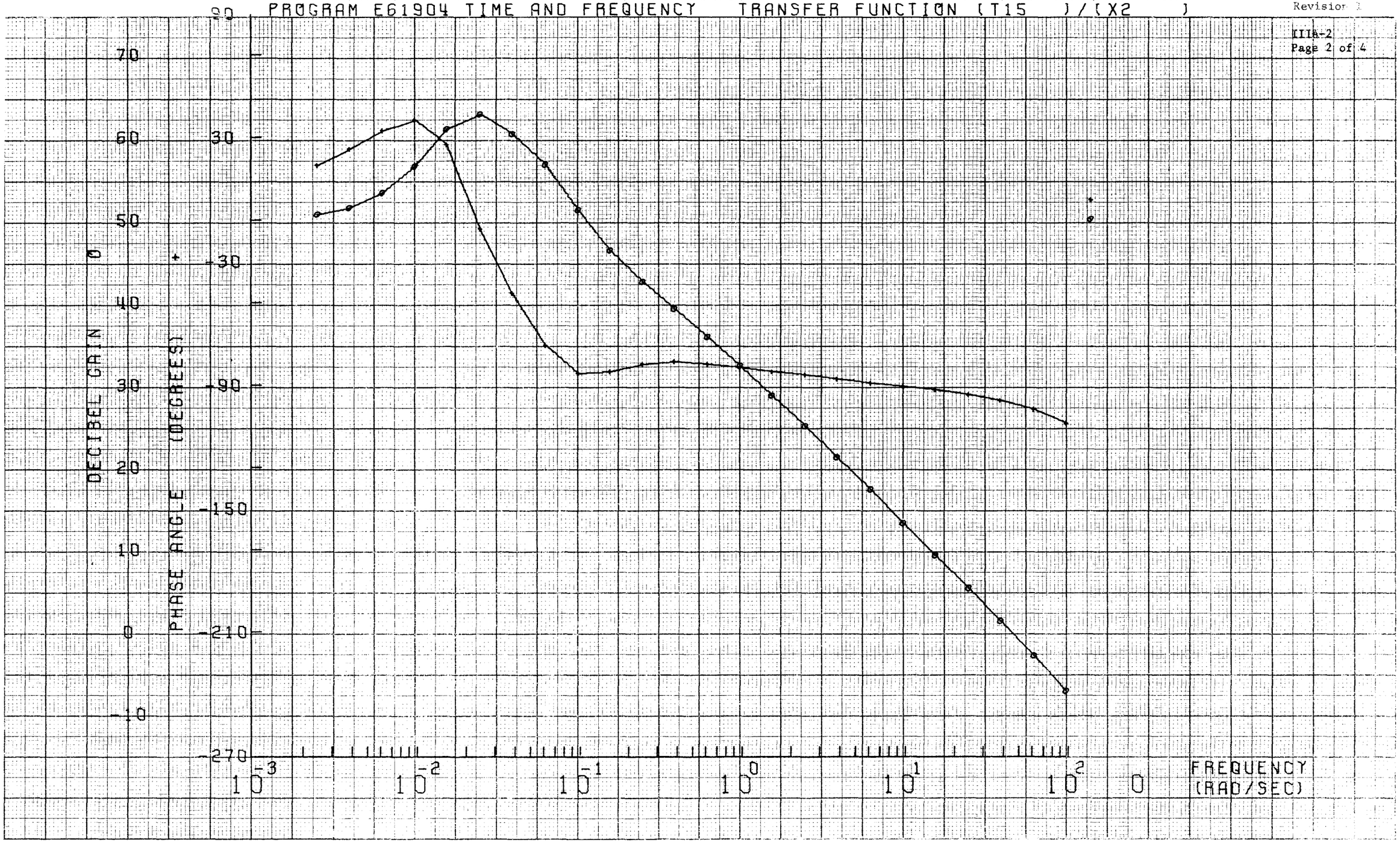
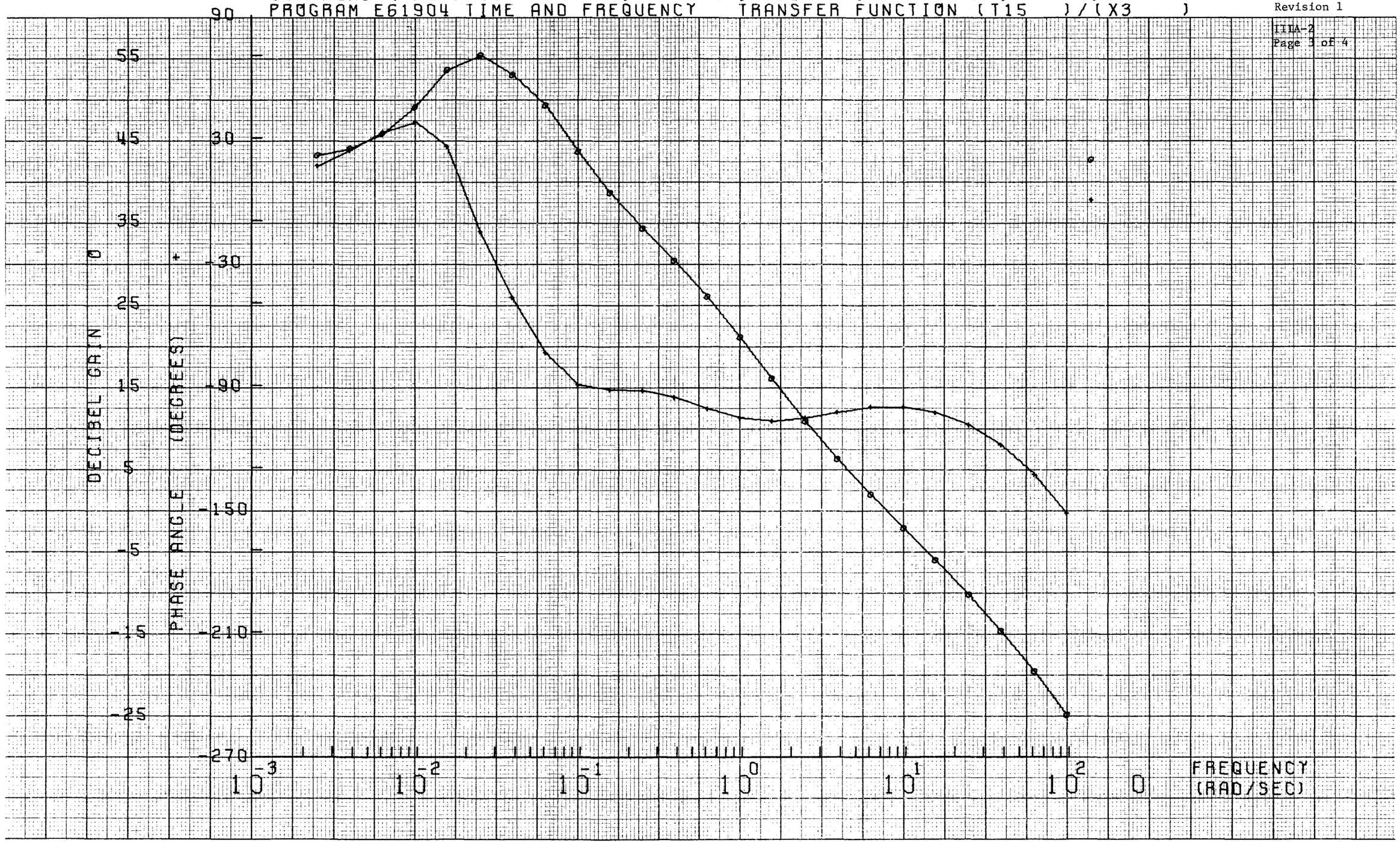
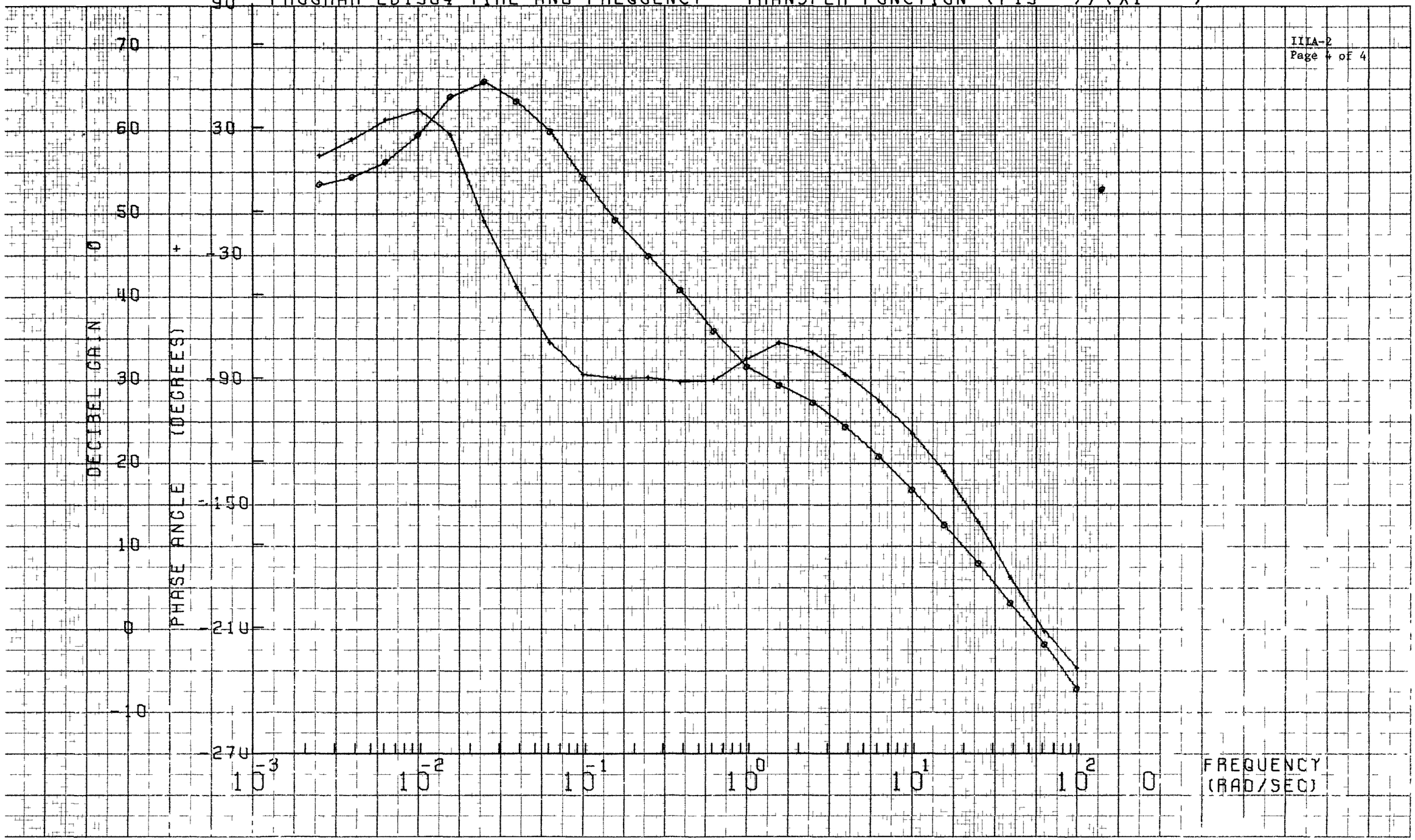
CONTRLRS & ACTS OUT P15=450.T15=4625.THSSV=47.53 X1=THV.X2=THD.X3=THSSV
PROGRAM E61904 TIME AND FREQUENCY TRANSFER FUNCTION (T15)/(X2)



CONTRLRS & ACTS OUT P15=450.T15=4625.THSSV=47.53 X1=THV.X2=THD.X3=THSSV
PROGRAM E61904 TIME AND FREQUENCY TRANSFER FUNCTION (T15)/(X3)



CONTRLRS & ACTS OUT P15=450.T15=4625.THSSV=47.53 X1=THV.X2=THD.X3=THSSV
PROGRAM E61904 TIME AND FREQUENCY TRANSFER FUNCTION (P15)/(X1)



STEADY STATE VARIABLES (V(I))

C11	1.660D 04		CI2	3.976D 03		CI3	1.693D 02		HC1	6.616D 01	
HC2	1.342D 02		RADKG	1.860D-02		HN	1.543D-02		HR	3.066D-00	
HSK	3.017D 01			0.0		P5	1.458D 02		P19	1.470D 02	
P20	1.451D 02		R29	3.789D 00		P29A	3.789D 00		PHP	6.230D 02	
PHSG	7.426D 02		PHT2	3.926D 02		PHT3	4.917D 02			0.0	
Q	3.866D -01		R7	2.586D-01		R10	1.657D-01		R15	1.128D-02	
R27	3.434D -02		R285	1.323D-02		[illegible]	[illegible]		R29	2.755D-03	
R29A	2.755D -03		R30	2.004D-03		[illegible]	[illegible]		RPM	2.535D 03	
RPMA	2.535D 03		RPMH	9.220D 03		RPMHA	9.220D 03		SN	5.652D 00	
T7	8.412D 01		T1C	1.052D 02		T15M	1.000D 03		T27	3.191D 02	
TNC	8.412D 01		TSKC	5.011D 01		[illegible]	[illegible]		THD	9.738D 01	
	9.738D 01			0.0		[illegible]	[illegible]		THDD3	0.0	
	4.753D 01		THSSV	4.753D 01		[illegible]	[illegible]		THV	2.667D 01	
	2.667D 01		THVA	2.667D 01			2.667D 01			2.667D 01	
THVD	2.667D 01		W4	1.280D 01		W4A	1.280D 01			0.0	
W5	1.918D 01		WNC	1.918D 01			0.0		CT27	2.045D-01	

CD	1.971D 03	COA	1.971D 03	COH	4.689D 03	COHA	4.689D 03	DKD	-7.939D-01
DKF	7.939D-01	DKT	-6.032D-07	ETH	4.754D-01	ETHA	4.764D-01	P3	3.000D 01
P3A	3.000D 01	P4	3.354D 01	P4A	3.354D 01	P45	1.477D 02	P45A	1.477D 02
	0.0		0.0		0.0		0.0	P7	1.069D 02
P10	9.272D 01	P15	6.000D 01	P15D	6.000D 01	P15E	-2.870D-08	P27	5.825D 01
P285	2.247D 01	P285A	2.247D 01	P30	2.755D 00	P31	0.0	P32	2.461D 00
PSS2	1.441D 02	PSS2E	1.171D 02	PHC	7.110D 02	PHC1	3.672D 02	PHC2	7.446D 02
	0.0		0.0		0.0		0.0	PHC3	1.032D 03
PHN	3.716D 02	PHR	1.134D 02	PHSK	2.326D 02	PHT2J	3.013D 02	PHT2PH	3.936D 02
PHT3J	4.888D 02	RC	3.584D-02	RSS	9.275D-02	RSS2	1.095D-01	RSS2E	6.293D-02
S	6.039D 00	SNQ	6.039D 00	T3	4.000D 01	T45	4.222D 01	T45A	4.222D 01
	0.0		0.0		0.0		0.0	T5	4.222D 01
T9	1.029D 02	T15	1.000D 03	T15D	1.000D 03	T15E	0.0	T20	4.222D 01
T22	3.200D 02	T29	2.585D 02	T29A	2.585D 02	T30	2.585D 02	T31	2.585D 02
T32	2.585D 02	TC1E	3.821D 02	TC2E	8.094D 02	TSS1	9.359D 01	TSS1E	1.450D 02
TSS2	2.473D 02	TSS2E	3.496D 02	TSS3	4.059D 02	TSS3E	4.228D 02	TSS4	3.714D 02
	0.0		0.0		0.0	TRQP	1.458D 01	TRQPA	1.458D 01
TRQPH	8.129D 01	TRQPHA	8.129D 01	TRQT	1.458D 01	TRQTA	1.458D 01	TRQTH	8.129D 01
TRQTHA	8.129D 01	THDD	9.738D 01	THDD1	0.0	THSSVD	4.753D 01	UCDH	8.519D-02
	0.0		0.0		0.0		0.0	UCDHA	8.519D-02
W27	9.582D-01	W31	9.582D-01	W32	9.582D-01	WC	2.489D 01	WDB	7.123D-01
WHB	2.459D-01	WN	2.465D 01	WP	1.280D 01	WPA	1.280D 01	WR	1.847D 01
WSS	1.604D 00	WSSB	4.820D 00	WSSI	1.604D 00	WT	4.791D-01	WTA	4.791D-01
	0.0	WTH	4.791D-01		0.0		0.0	WTHA	4.791D-01
WV	4.791D-01	WVA	4.791D-01						

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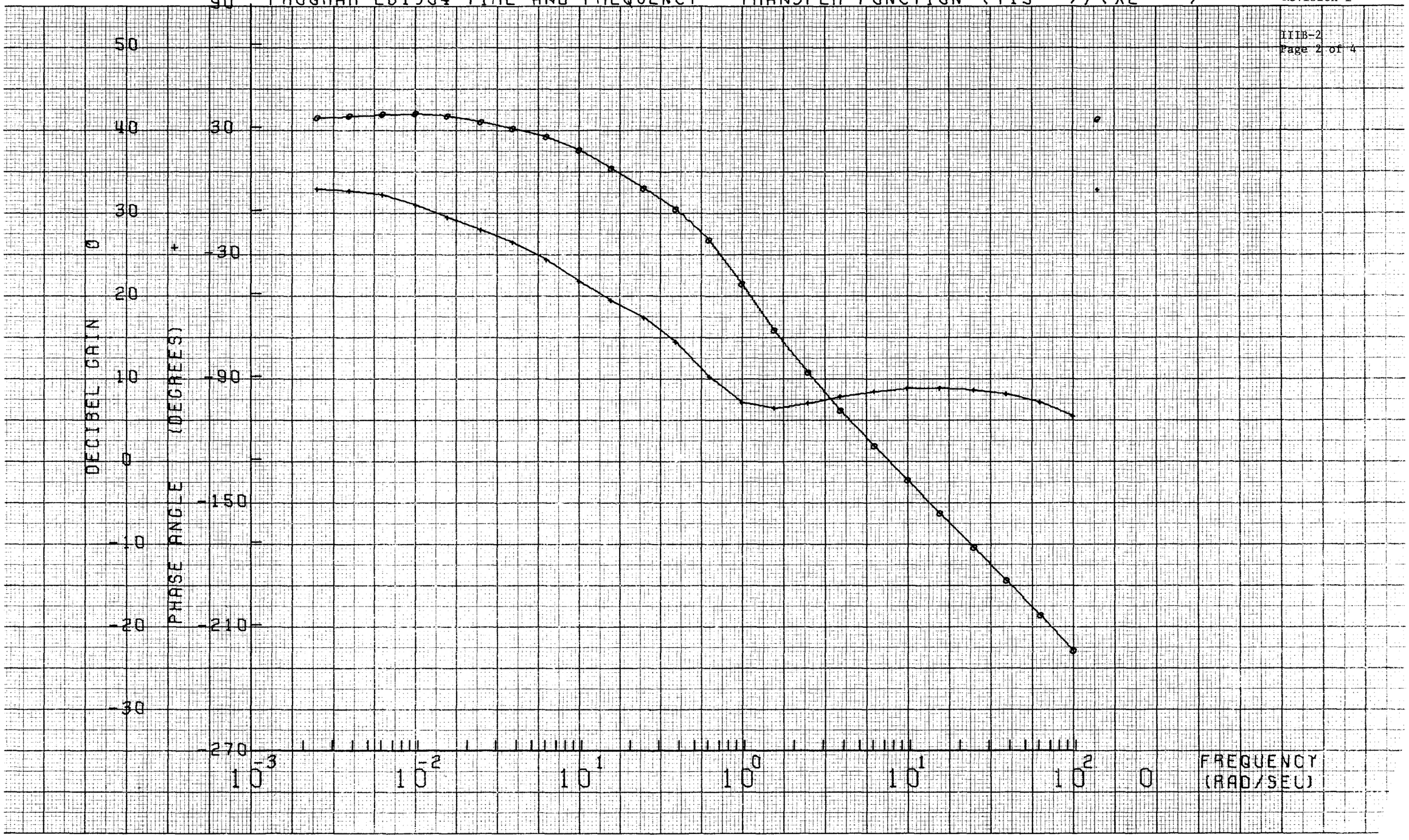
(RAD./SEC.)	$\frac{\Delta T_{15}}{\Delta\theta_V}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta T_{15}}{\Delta\theta_d}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta T_{15}}{\Delta\theta_{SSV}}$ MAGNITUDE	DECIBELS	PHASE
1.000D-07	2.719D 02	48.687	-0.000	1.127D 02	41.039	0.000	2.342D 00	7.392	-180.000
2.500D-03	2.781D 02	48.885	-0.931	1.147D 02	41.192	0.211	2.404D 00	7.617	-180.019
3.950D-03	2.850D 02	49.097	-2.444	1.170D 02	41.361	-0.392	2.472D 00	7.860	-181.116
6.280D-03	2.944D 02	49.378	-6.333	1.202D 02	41.595	-2.511	2.567D 00	8.189	-184.495
1.000D-02	2.972D 02	49.460	-13.973	1.216D 02	41.701	-7.067	2.609D 00	8.331	-191.503
1.570D-02	2.811D 02	48.976	-24.352	1.177D 02	41.416	-13.163	2.488D 00	7.916	-200.929
2.500D-02	2.464D 02	47.831	-35.865	1.097D 02	40.726	-19.342	2.208D 00	6.879	-211.123
3.950D-02	2.083D 02	46.374	-47.616	9.896D 01	39.909	-25.359	1.908D 00	5.609	-221.092
6.280D-02	1.707D 02	44.644	-63.044	8.818D 01	38.907	-33.548	1.618D 00	4.179	-234.409
1.000D-01	1.280D 02	42.141	-84.198	7.325D 01	37.296	-44.018	1.272D 00	2.091	-253.327
1.570D-01	8.510D 01	38.598	-108.339	5.673D 01	35.076	-53.271	8.937D-01	-0.977	84.659
2.500D-01	5.007D 01	33.991	-135.383	4.297D 01	32.662	-61.517	5.557D-01	-5.109	59.312
3.950D-01	2.636D 01	28.419	-170.680	3.240D 01	30.209	-73.297	3.077D-01	-10.238	30.485
6.280D-01	1.091D 01	20.755	-212.563	2.118D 01	26.516	-90.111	1.430D-01	-16.893	1.690
1.000D 00	3.510D 00	10.906	-252.905	1.143D 01	21.160	-102.292	6.700D-02	-23.478	-18.586
1.570D 00	1.090D 00	0.751	73.648	6.057D 00	15.645	-105.013	3.796D-02	-28.413	-30.691
2.500D 00	3.389D-01	-9.399	42.669	3.341D 00	10.477	-102.743	2.274D-02	-32.862	-55.522
3.950D 00	1.099D-01	-19.177	14.852	1.977D 00	5.921	-99.542	1.393D-02	-37.118	-71.186
6.280D 00	3.280D-02	-29.683	-10.439	1.205D 00	1.623	-97.044	8.407D-03	-41.507	-83.687
1.000D 01	7.408D-03	-30.000	-32.689	7.468D-01	-2.535	-95.682	4.953D-03	-46.102	-93.396
1.570D 01	1.755D-04	-30.000	-60.876	4.728D-01	-6.507	-95.449	2.892D-03	-50.777	-100.353
2.500D 01	1.487D-03	-30.000	-245.008	2.956D-01	-10.586	-96.354	1.640D-03	-55.704	-104.976
3.950D 01	1.423D-03	-30.000	-260.021	1.859D-01	-14.612	-98.573	9.541D-04	-60.409	-107.985
6.280D 01	1.049D-03	-30.000	86.167	1.154D-01	-18.758	-102.595	5.706D-04	-64.872	-111.919
1.000D 02	7.122D-04	-30.000	67.663	7.015D-02	-23.079	-109.060	3.535D-04	-69.031	-120.787

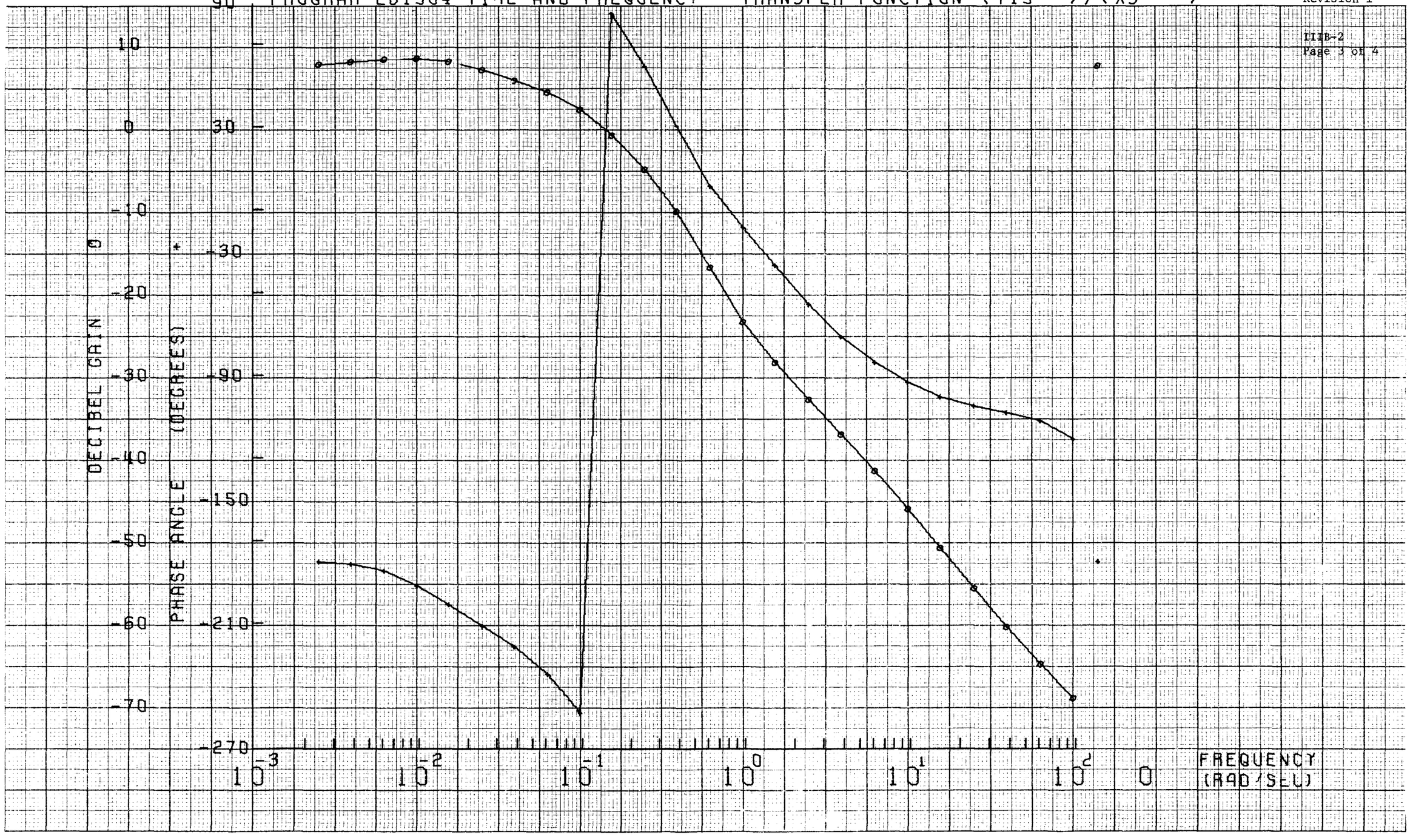
(RAD./SEC.)	$\frac{\Delta P_{15}}{\Delta\theta_V}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta P_{15}}{\Delta\theta_d}$ MAGNITUDE	DECIBELS	PHASE	$\frac{\Delta P_{15}}{\Delta\theta_{SSV}}$ MAGNITUDE	DECIBELS	PHASE
1.000D-07	2.166D 01	26.712	0.000	5.697D 00	15.113	0.000	2.126D-01	-13.447	-180.000
2.500D-03	2.205D 01	26.867	0.109	5.822D 00	15.302	1.345	2.165D-01	-13.292	-179.141
3.950D-03	2.249D 01	27.038	-0.561	5.966D 00	15.514	1.267	2.208D-01	-13.119	-179.362
6.280D-03	2.312D 01	27.279	-2.781	6.185D 00	15.827	-0.190	2.273D-01	-12.868	-180.844
1.000D-02	2.344D 01	27.398	-7.551	6.353D 00	16.059	-4.011	2.314D-01	-12.712	-184.456
1.570D-02	2.273D 01	27.133	-14.098	6.283D 00	15.963	-9.379	2.268D-01	-12.888	-189.395
2.500D-02	2.100D 01	26.443	-21.228	6.002D 00	15.576	-15.145	2.139D-01	-13.396	-194.349
3.950D-02	1.889D 01	25.525	-28.769	5.714D 00	15.139	-21.821	1.990D-01	-14.021	-199.361
6.280D-02	1.622D 01	24.203	-38.726	5.302D 00	14.489	-32.208	1.794D-01	-14.921	-206.294
1.000D-01	1.246D 01	21.907	-49.542	4.515D 00	13.094	-46.357	1.480D-01	-16.592	-213.955
1.570D-01	8.562D 00	18.651	-55.944	3.501D 00	10.884	-60.580	1.128D-01	-18.955	-216.834
2.500D-01	5.897D 00	15.412	-52.303	2.559D 00	8.161	-75.459	8.767D-02	-21.143	-212.159
3.950D-01	4.948D 00	13.888	-45.257	1.760D 00	4.910	-94.786	7.852D-02	-22.100	-206.211
6.280D-01	4.544D 00	13.148	-52.096	9.710D-01	-0.256	-118.562	7.359D-02	-22.663	-207.100
1.000D 00	3.610D 00	11.150	-66.722	4.139D-01	-7.662	-133.926	6.326D-02	-23.977	-210.572
1.570D 00	2.529D 00	8.059	-81.156	1.744D-01	-15.170	-134.265	5.284D-02	-25.540	-211.215
2.500D 00	1.633D 00	4.257	-95.181	8.113D-02	-21.816	-126.018	4.528D-02	-26.881	-210.269
3.950D 00	1.017D 00	0.145	-109.618	4.349D-02	-27.234	-117.035	4.048D 02	-27.854	-210.674
6.280D 00	6.055D-01	[illegible]	[illegible]	2.472D-02	-32.138	-110.211	3.653D-02	-28.746	-214.489
1.000D 01	3.490D-01	[illegible]	-145.932	1.422D-02	-36.944	-105.178	3.202D-02	-29.892	-222.366
1.570D 01	2.033D-01	-13.837	-167.264	8.234D-03	-41.687	-99.517	2.641D-02	-31.564	-233.387
2.500D 01	1.199D-01	-18.427	-189.529	4.839D-03	-46.320	-89.595	1.972D-02	-34.102	-246.616
3.950D 01	7.536D-02	-22.457	-208.499	3.266D-03	-49.719	-77.002	1.344D-02	-37.432	-259.375
6.280D 01	4.947D-02	-26.113	-223.446	2.572D-03	-51.770	-69.523	8.434D-03	-41.479	-266.857
1.000D 02	3.217D-02	-29.850	-232.371	2.135D-03	-53.412	-72.870	5.500D-03	-45.193	83.135

UNCLASSIFIED

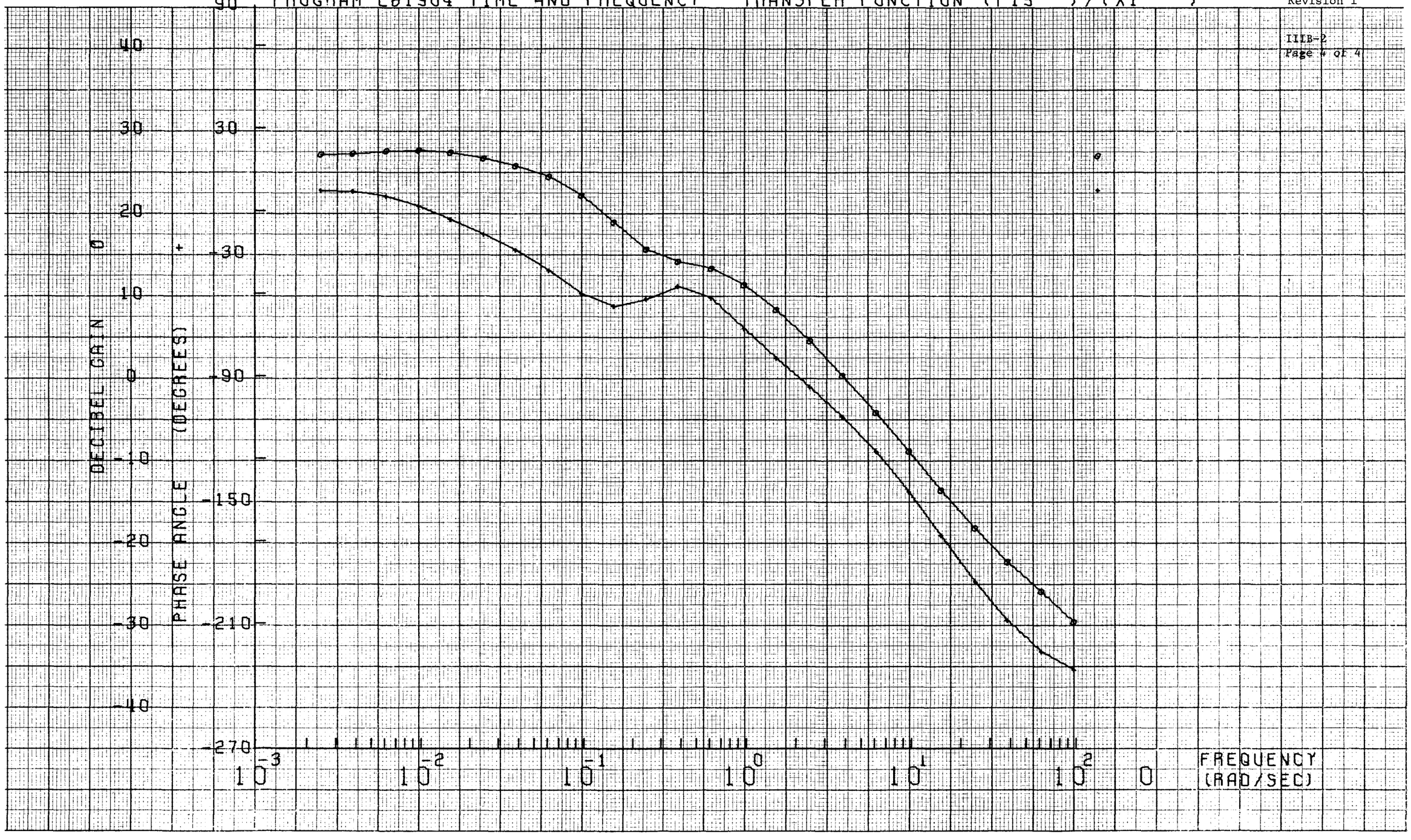
CONTRLRS ¢ ACTS OUT P15= 60.T15=1000.THSSV=47.53 X1=THV.X2=THD.X3=THSSV
PROGRAM E61904 TIME AND FREQUENCY TRANSFER FUNCTION (T15)/(X2)



CONTRLRS & ACTS OUT P15 = 60.T15=1000.THSSV=47.53 X1=THV.X2=THD.X3=THSSV
PROGRAM E61904 TIME AND FREQUENCY TRANSFER FUNCTION (T15)/(X3)



CONTRLRS & ACTS OUT P15 = 60, T15=1000, THSSV=47.53 X1=THV, X2=THD, X3=THSSV
PROGRAM E61904 TIME AND FREQUENCY TRANSFER FUNCTION (P15)/(X1)



Variables
Equation, Fortran

CI_j	=	Precursor concentration in j^{th} group	
Co	=	Isentropic spouting velocity	ft/sec
Dk_d	=	Reactivity feedback of drums	$
Dk_f	=	Reactivity feedback of reactor	$
Dk_t	=	Total reactivity feedback	$
ET	=	Turbine efficiency	
f	=	Function	
H	=	Enthalpy of solid material	BTU/lb
M, TRQ	=	Torque	lb-ft
N, RPM	=	Speed	rpm
P	=	Pressure	psia
Q	=	Decay heat power	%
R	=	Density	lb/ft^3
s	=	Laplace operator	
S	=	Thermal power in fueled sections	%
S_N	=	Nuclear power	%
S_{NQ}	=	Thermal power in unfueled sections	%
t	=	Time	sec
T	=	Fluid Temperature	^oR
u	=	Mean peripheral blade speed	ft/sec
W	=	Mass flowrate	lb/sec
θ, TH	=	Angular position	deg
φ, PH	=	Material temperature	^oR

Station

3	=	Pump inlet
4	=	Low speed pump discharge
45	=	High speed pump discharge
5	=	Nozzle inlet
7	=	Reflector inlet plenum
9	=	Peripheral shield exit plenum
10	=	Dome end plenum
15	=	Nozzle chamber
19	=	Support structure bypass control valve inlet
20	=	Support structure control valve discharge
22	=	Support system discharge
27	=	TPCV inlet
285	=	High speed turbine inlet
29	=	Low speed turbine inlet
30	=	Low speed turbine exit
31	=	Skirt extension inlet
32	=	Skirt extension outlet

Qualifying Subscripts
Equation, Fortran

a	=	Parallel turbopump
C	=	Reactor core, average
C_i	=	Reactor core, i^{th} section

Qualifying Subscripts (continued)
Equation, Fortran

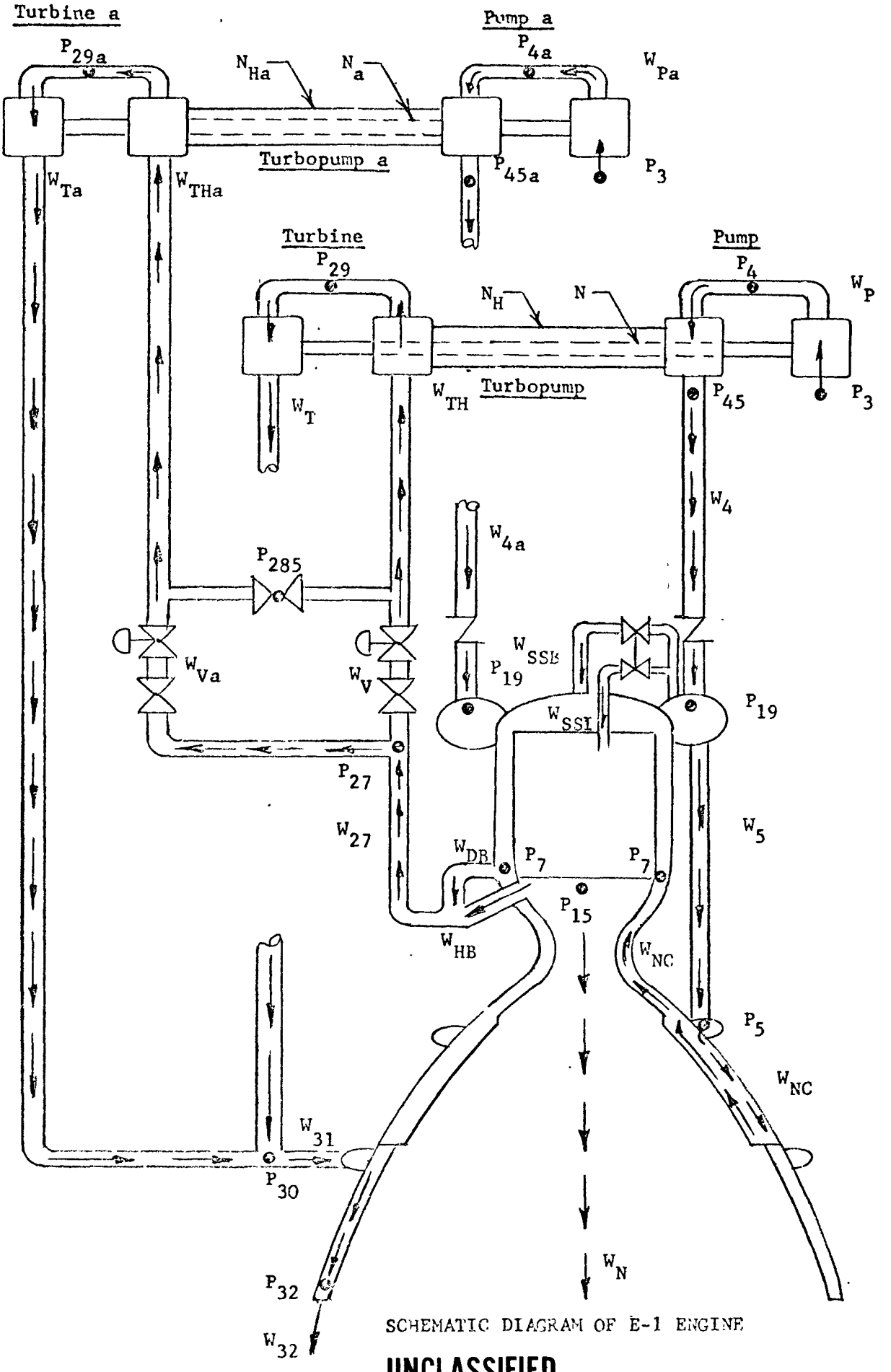
d	=	Drum
D	=	Demand
DB	=	Diluent bleed
e	=	Exit
E	=	Error
EC	=	Clamped error
EXT	=	Skirt extension
H	=	High speed
HB	=	Hot bleed
j	=	Radial inside
M	=	Measured
N	=	Nozzle
NC	=	Nozzle coolant
p	=	Pyrographite
P	=	Pump
R	=	Reflector
SG	=	Structural graphite
SK	=	Skirt
SKC	=	Skirt coolant
SS	=	Support system average
SSB	=	Support system bypass
SSI	=	Support system inlet
SSj	=	Support system, j^{th} section
ssv	=	Support system control valve
T	=	Turbine

Qualifying Subscripts (continued
Equation, Fortran

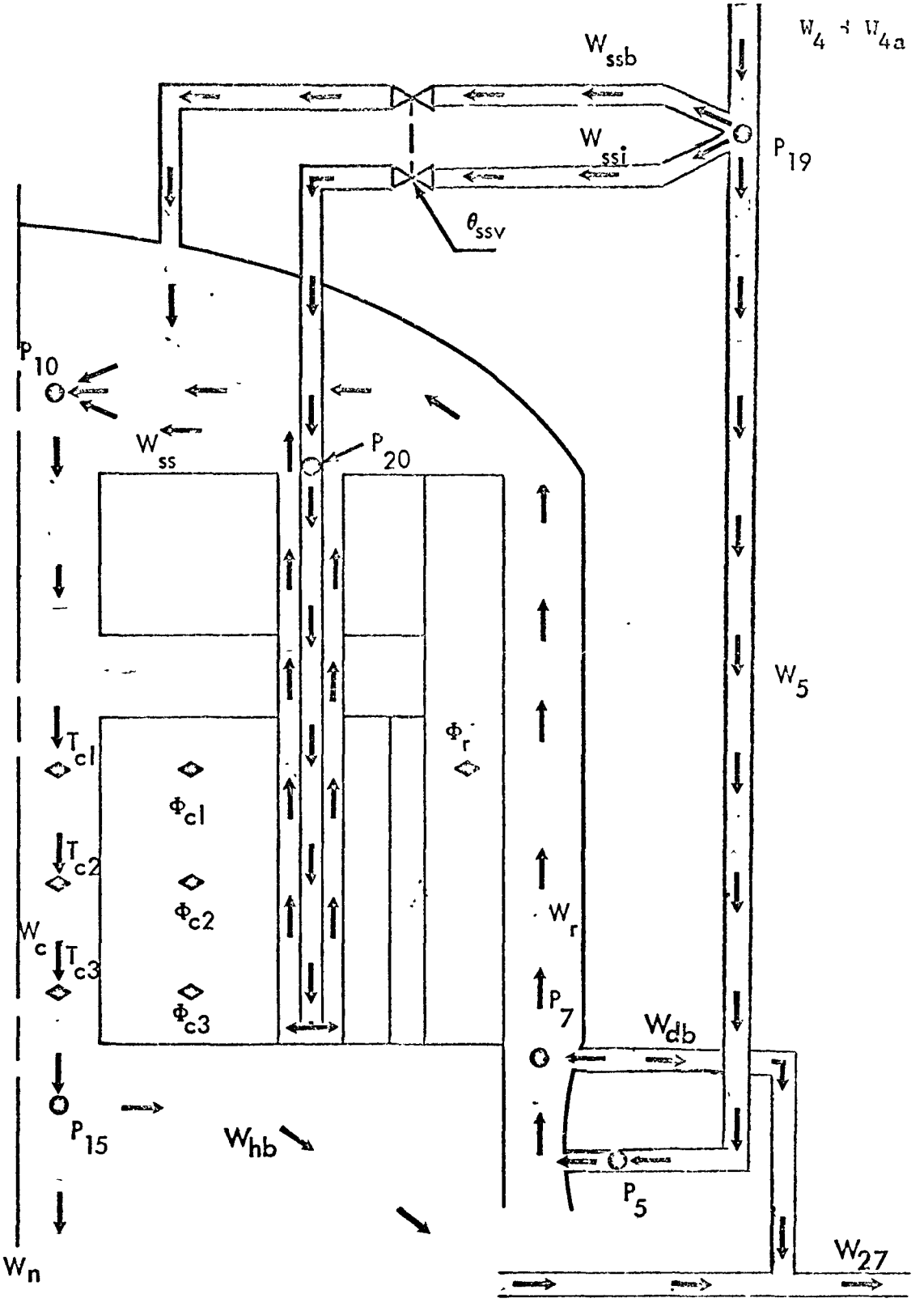
ti = Stainless steel, i^{th} section

V = Turbine power control valve

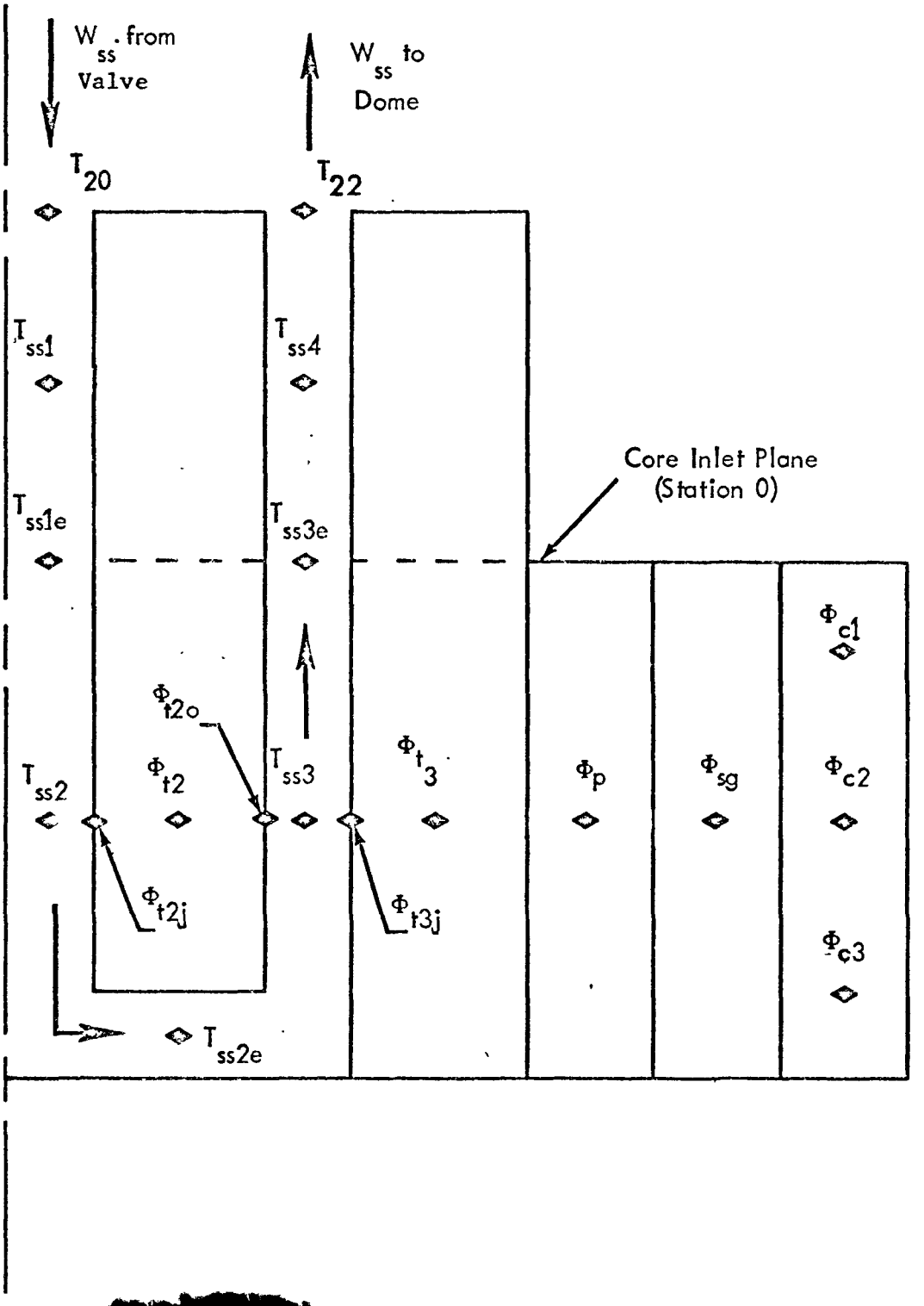
φ,PH = Radial outside



SCHEMATIC DIAGRAM OF E-1 ENGINE



SCHEMATIC DIAGRAM OF E-1 NUCLEAR SUBSYSTEM



TIC DIAGRAM OF SUPPORT SYSTEM