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HR **TEXTRON**

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(NASA-CR-175470) COMPENSATOR DEVELOPMENT
AND EXAMINATION OF PERFORMANCE AND
ROBUSTNESS (Hydraulic Research Textron)
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Report #956541-Extension 1

REPORT ON

COMPENSATOR DEVELOPMENT AND EXAMINATION

OF PERFORMANCE AND ROBUSTNESS



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1.0 INTRODUCTION

In this report, a compensator has been synthesized which minimizes the mean-square surface error of the antenna described in section 2 of Ref. [1]. The compensator is based on the techniques documented in Ref. [1].

2.0 COMPENSATOR BASED ON MEAN-SQUARE SURFACE ERROR IN PERFORMANCE INDEX

The performance index for the optimal control problem for the antenna has the form

$$J = \int_0^{\infty} (\langle Qz, z \rangle + r u^2) dt,$$

where z is the state vector and u is the control torque. For the compensator in this report, the operator Q was chosen so that $\langle Qz, z \rangle$ is

$$q_1 \theta^2 + q_2 \dot{\theta}^2 + q_3 \int_{A_{\text{mesh}}} W_{\text{mesh}}^2 dA_{\text{mesh}},$$

where θ is the rigid body angle and W_{mesh} is the displacement of the mesh reflecting surface from the position in which the rigid-body rotation and all elastic deformations are zero.

In choosing the weighting coefficients q_1 , q_2 , q_3 and r , we took the mean-square surface error weighted by q_3 as the primary term to be minimized, but we also considered the response time and overshoot of the rigid-body angle to be

secondary objectives. After considerable analysis and numerical experimentation with different sets of q_1 , q_2 , q_3 and r we selected

(CASE 1) $q_1 = 0.$, $q_2 = 0.$, $q_3 = 374.$, $r = .0001.$

The estimator used in the compensator is the same one used in the compensator described in the Ref. [1]

Figures 1 and 2 show the Bode plots of the ideal compensator for Case 1. The compensator has three channels. Channel 1, shown in Figure 1, is from the hub rotation sensor to the torque actuator. Channels 2 and 3 are from each of the two rib tip displacement sensors to the torque actuator, and because of the antenna symmetry, these channels have identical transfer functions. The frequency response of Channel 2 (or 3) is shown in Figure 2. Figure 3 shows the response of the rigid-body angle, the mean square surface error

$$\text{RMS} = \int_{A_{\text{mesh}}} w_{\text{mesh}}^2 dA_{\text{mesh}} ,$$

and the control $u(t)$ for the initial condition consisting of an initial rigid-body rotation only.

For comparison, we computed the compensator for (CASE 2) $q_1 = 74.$, $q_2 = 0.$, $q_3 = 0.$, $r = .0001.$ If the antenna were rigid, CASE 1 and CASE 2 would be equivalent.

BODE DIAGRAM

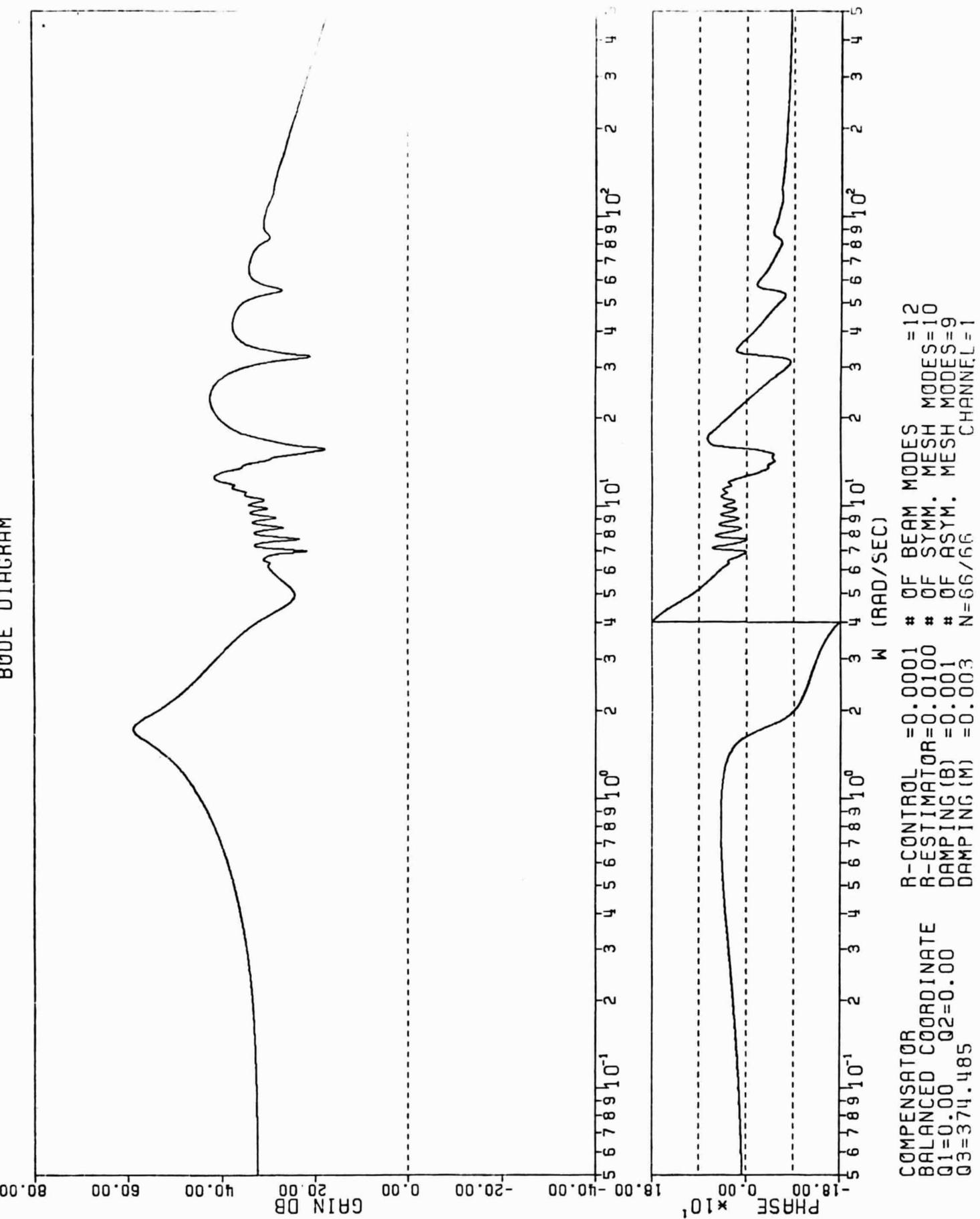
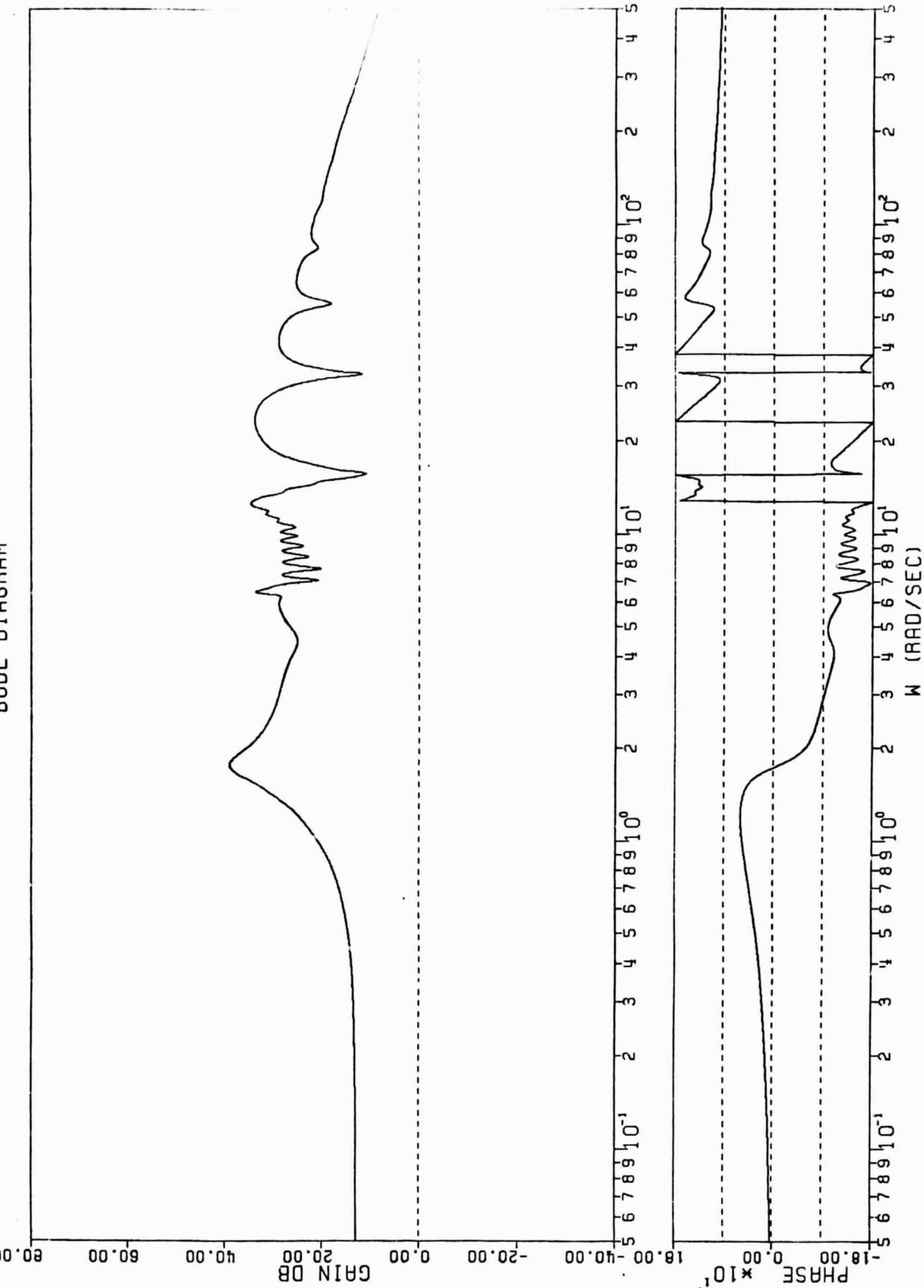


Figure 1



COMPENSATOR BALANCED COORDINATE Q1=0.00 Q2=0.00 Q3=374.485
 R-CONTROL =0.0001 # OF BEAM MODES =12
 R-ESTIMATOR=0.0100 # OF SYMM. MESH MODES=10
 DAMPING (B) =0.001 # OF ASYM. MESH MODES=9
 DAMPING (M) =0.003 N=66/66 CHANNEL=2

Figure 2

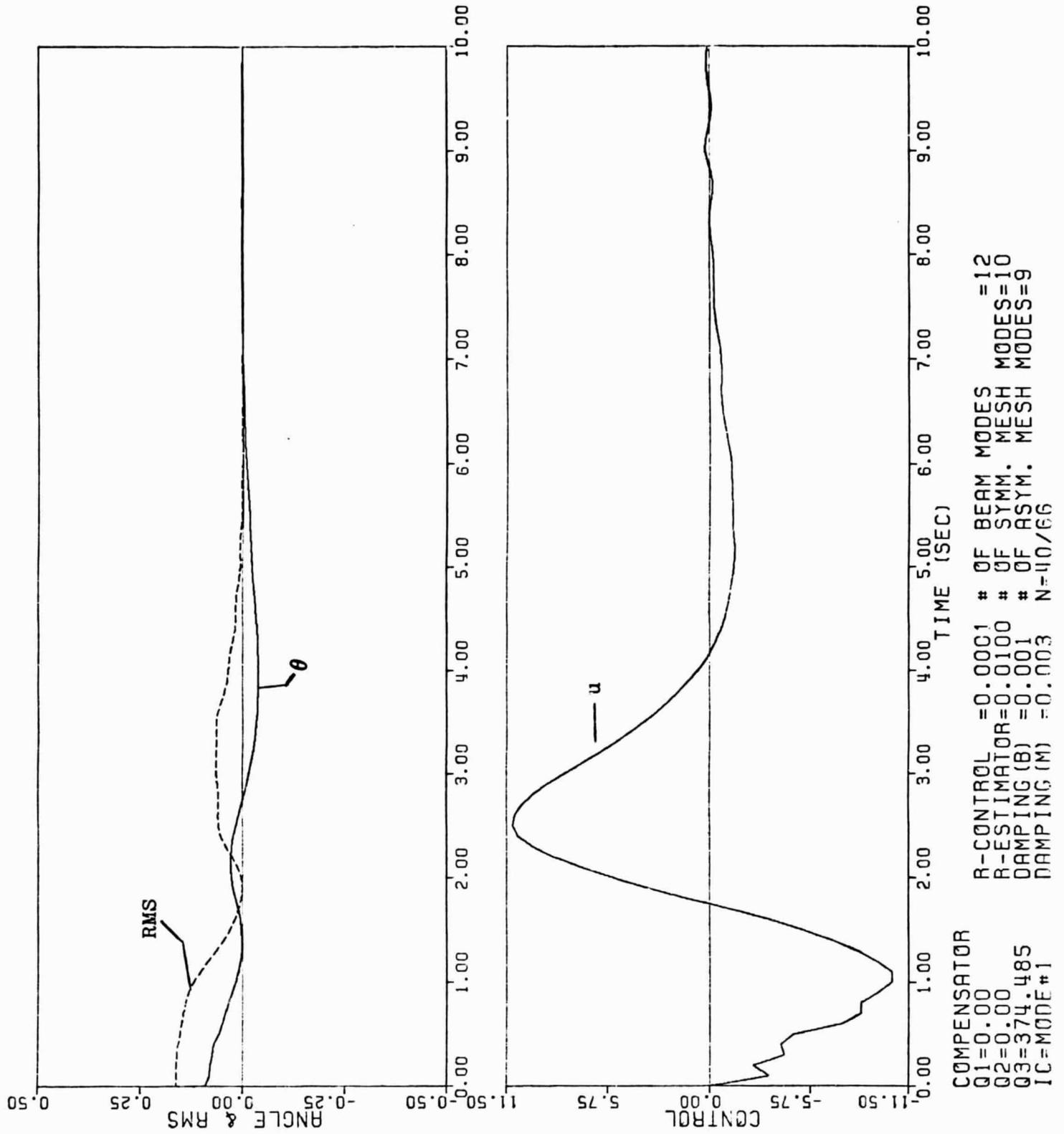


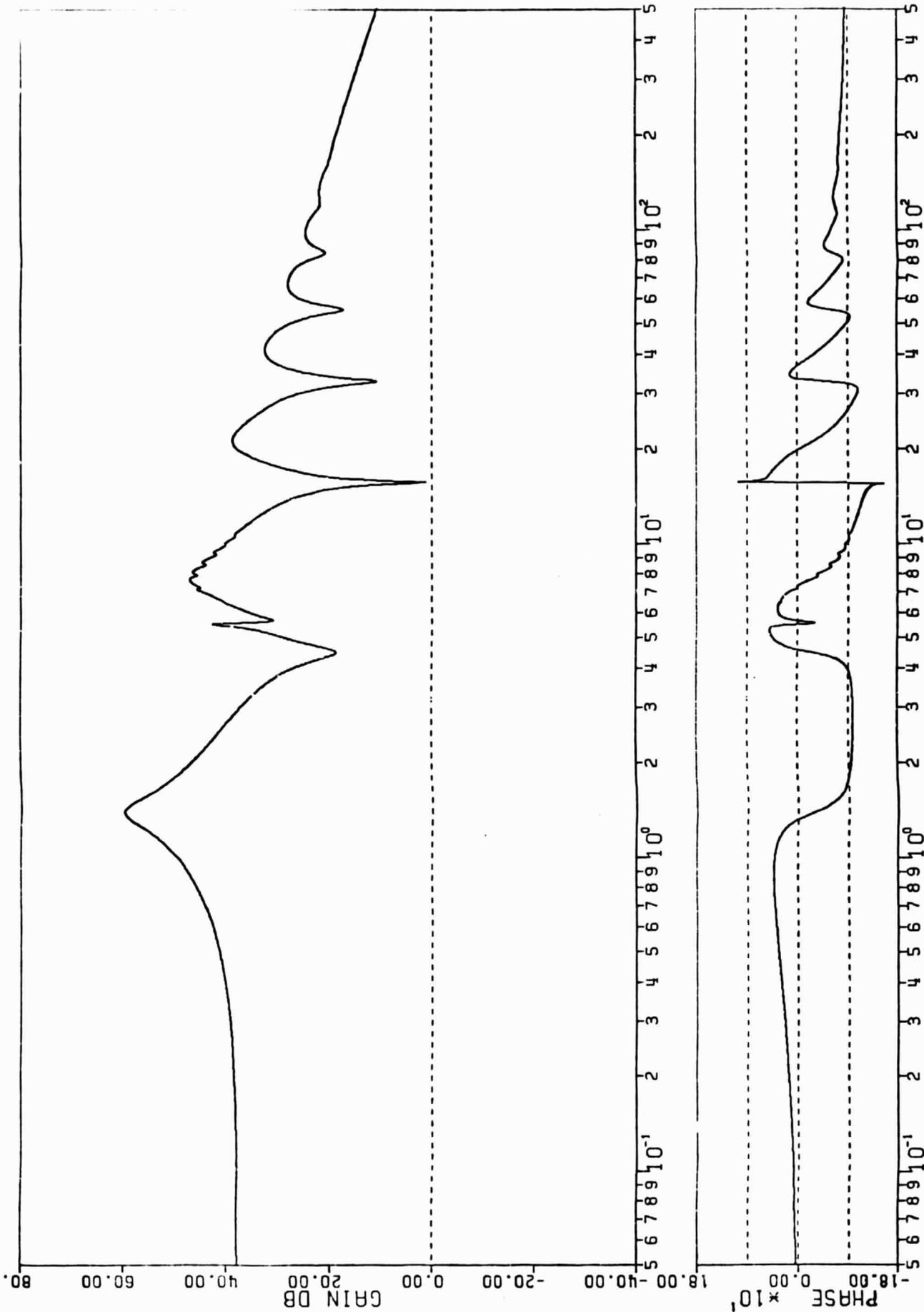
Figure 3

The comparison then illustrates the difference, in the presence of flexible ribs and mesh, between penalizing the actual error of the reflecting surface and penalizing just the rigid-body rotation. Figure 4 and 5 show the Bode plots for Channels 1 and 2 of the CASE 2 compensator, and Figure 6 shows the corresponding rigid-body angle, mean-square surface error and the control $u(t)$ for the initial condition consisting of an initial rigid-body rotation only.

Note that the Bode plots appear to indicate that the compensator for CASE 1 takes the mesh modes into account significantly, while the compensator for CASE 2 virtually ignores the mesh. Figures 3 and 6 appear to confirm this interpretation, since the compensator for CASE 1 produces significantly less mean-square surface error.

3.0 CONCLUSION

A compensator has been synthesized to minimize the mean-square surface error of the wrap-rib antenna. The numerical results show that the flexible modes of the antenna have to be included in the performance criterion to obtain a better performance.



COMPENSATOR BALANCED COORDINATE Q1=73.53 Q2=0.00 Q3=0.00
 R-CONTROL =0.0001 # OF BEAM MODES =12
 R-ESTIMATOR=0.0100 # OF SYMM. MESH MODES=10
 DAMPING (B) =0.001 # OF ASYM. MESH MODES=9
 DAMPING (M) =0.003 N=66/66 CHANNEL=1

Figure 4

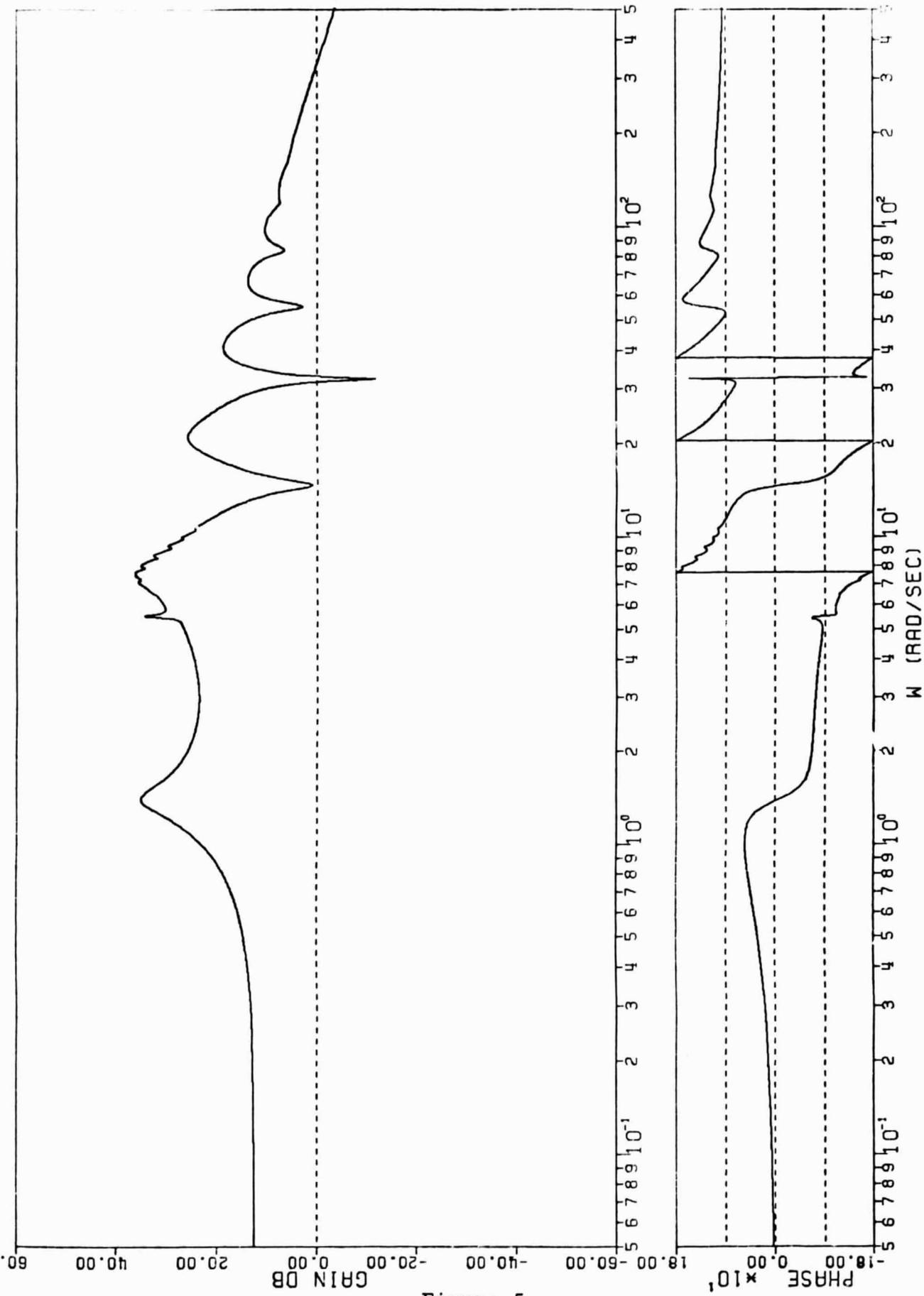
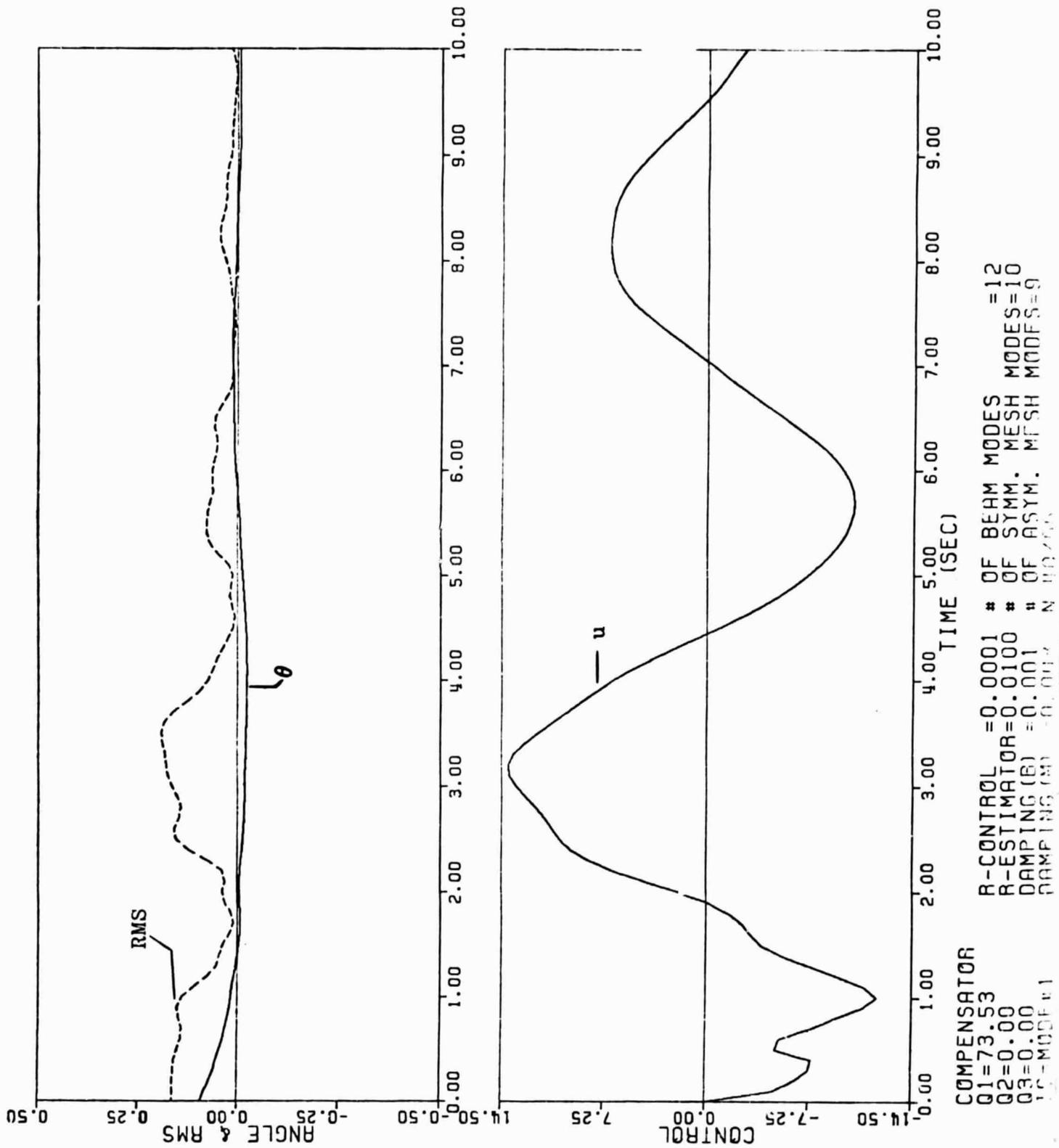


Figure 5

COMPENSATOR BALANCED COORDINATE Q1=73.53 Q2=0.00 Q3=0.00
 R-CONTROL =0.0001 # OF BEAM MODES =12
 R-ESTIMATOR=0.0100 # OF SYMM. MESH MODES=10
 DAMPING (B) =0.001 # OF ASYM. MESH MODES=9
 DAMPING (M) =0.003 N=66/66 CHANNEL=2



COMPENSATOR
 Q1=73.53
 Q2=0.00
 Q3=0.00
 TYPE=MODE u1

R-CONTROL =0.0001 # OF BEAM MODES =12
 R-ESTIMATOR=0.0100 # OF SYMM. MESH MODES=10
 DAMPING (B) =0.001 # OF ASYM. MESH MODES=9
 DAMPING (M) =0.001 N 10/2/65

Figure 6

REFERENCES

- [1] HR Textron: Final Report, "Integrated Control/Structure Research for Large Space Structures" Report #956541-Final, September, 1984.