N87-22706

MICROPROCESSOR CONTROLLED PROOF-MASS ACTUATOR

BY

GARNETT C. HORNER
STRUCTURAL DYNAMICS BRANCH
LANGLEY RESEARCH CENTER
HAMPTON, VA 23665

PRECEDING PAGE BLANK NOT FILMED

MICROPROCESSOR CONTROLLED PROOF-MASS ACTUATOR

The objective of the microprocessor controlled proof-mass actuator is to develop the capability to mount a small programmable device on laboratory models. This capability will allow research in the active control of flexible structures.

The approach in developing the actuator will be to mount all components as a single unit. All sensors, electronic and control devices will be mounted with the actuator. The goal for the force output capability of the actuator will be one pound force.

MICROPROCESSOR CONTROLLED PROOF–MASS ACTUATOR

OBJECTIVE:

TO DEVELOP A SMALL PROGRAMMABLE ACTUATOR THAT CAN BE MOUNTED ON LABORTORY MODELS FOR THE PURPOSE OF CONDUCTING CONTROL RESEARCH.

APPROACH:

TO MOUNT AS A UNIT:

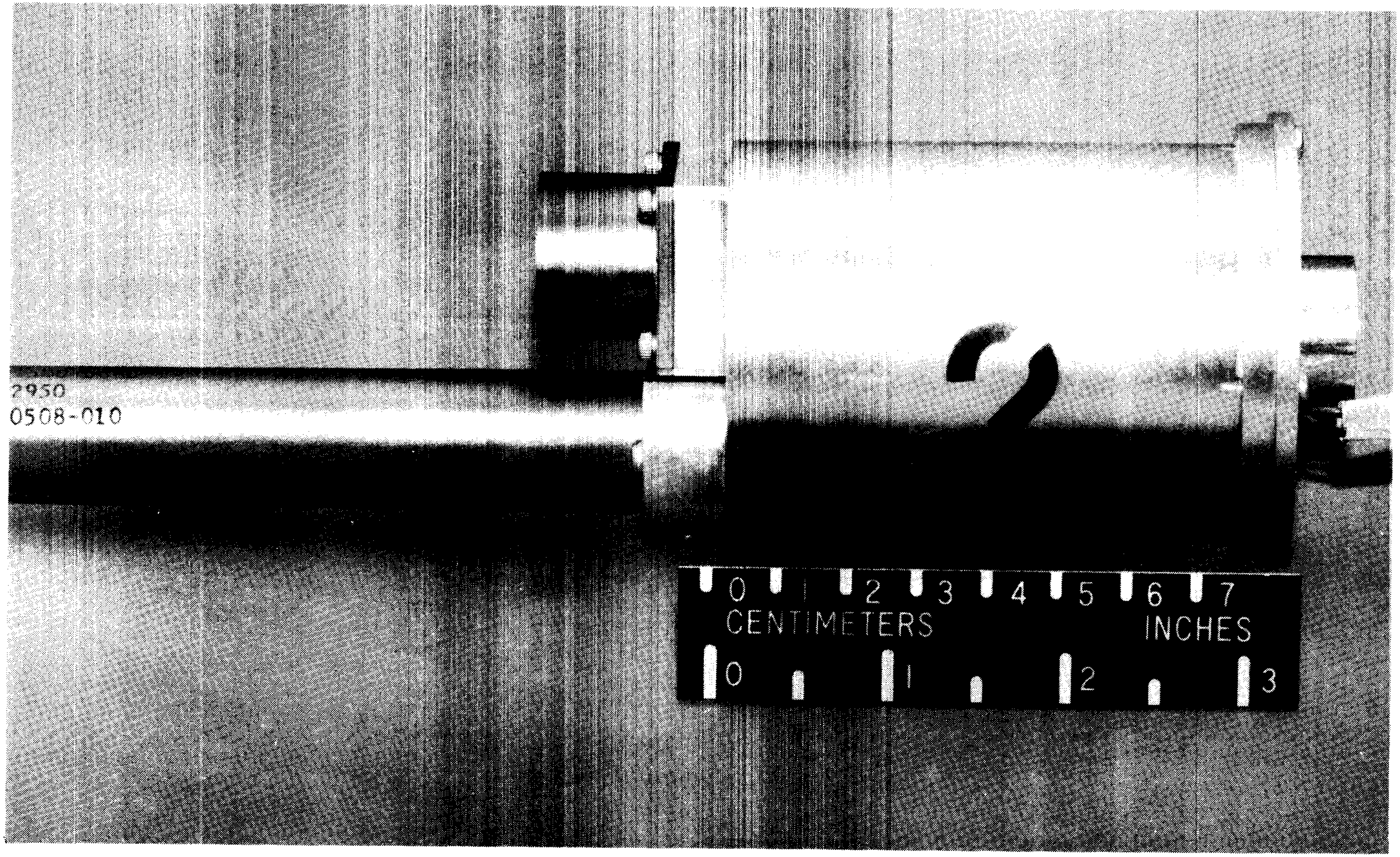
- A ONE POUND FORCE ACTUATOR
- A MICROCONTROLLER CIRCUIT
- A POWER AMPLIFIER
- COLOCATED ACCELEROMETER

PROOF-MASS ACTUATOR

The proof-mass actuator consists of a cylindrical section approximately 3 inches in length. Internal to this section is the proof-mass which is a small cylinder of magnet iron. The proof-mass rides on linear ball bearings and contains two small samarium cobalt `donut' magnets. There is also a wound copper coil that energizes the proof-mass. The electerical leads to the coil can be seen on the extreme right. The small hub on the right is the structural attachment point.

The two smaller cylindrical sections protruding to the left of the actuator are the colocated sensors. The longer of the two is a linear variable differential transformer (LVDT) that measures the position of the proof-mass. The smaller cylinder is an accelerometer that measures acceleration of the structure.

PROOF-MASS ACTUATOR

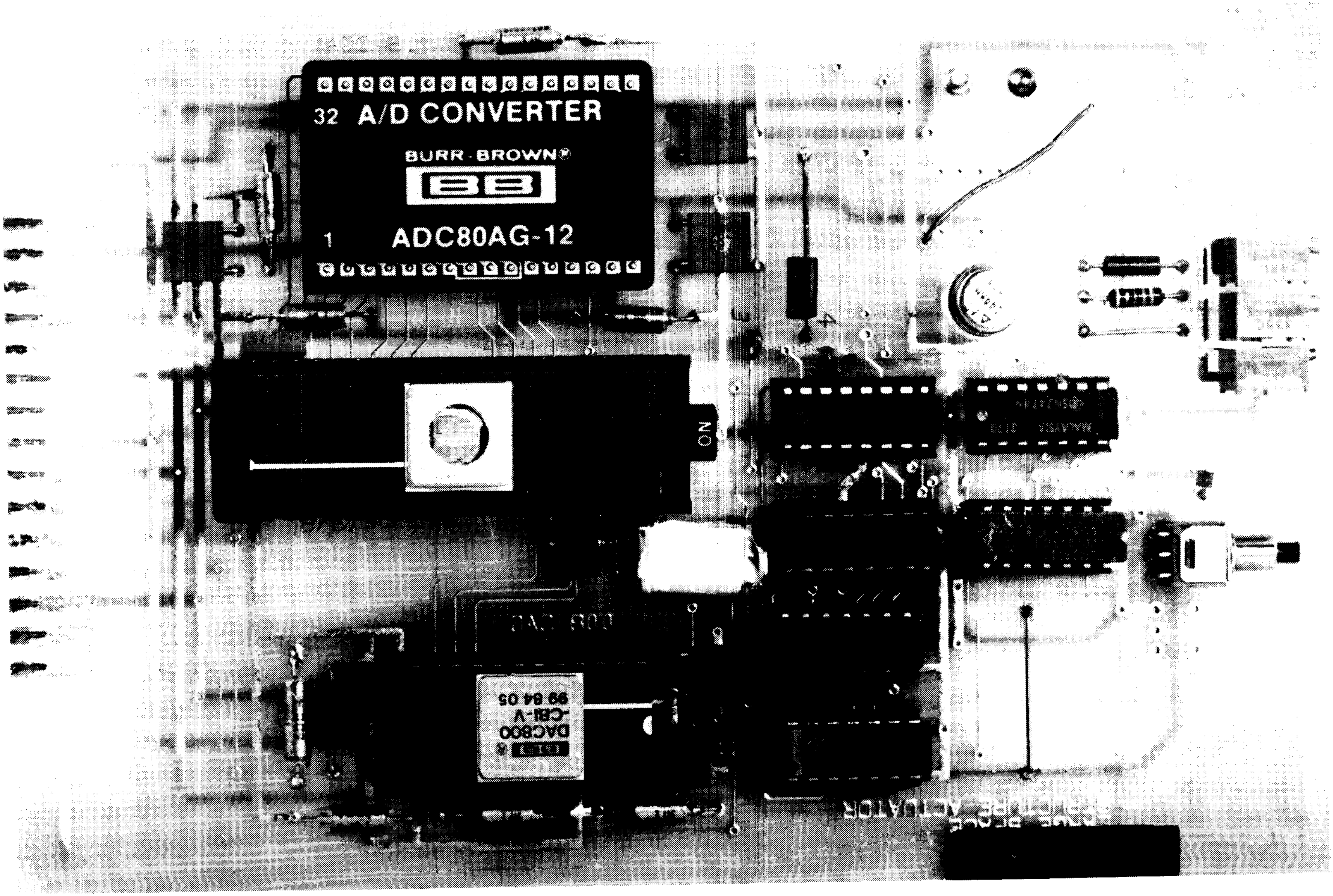


MICROPROCESSOR CONTROLLER BOARD

The microprocessor controller board contains three primary components. The analog-to-digital converter (ADC) and a switching circuit that selects one of three analog inputs. The output of the ADC connects to two of the ports of the microprocessor which is an Intel 8751. The output of the 8751 goes to a digital-to-analog converter (DAC) which in turn connects to the input of the power amplifer.

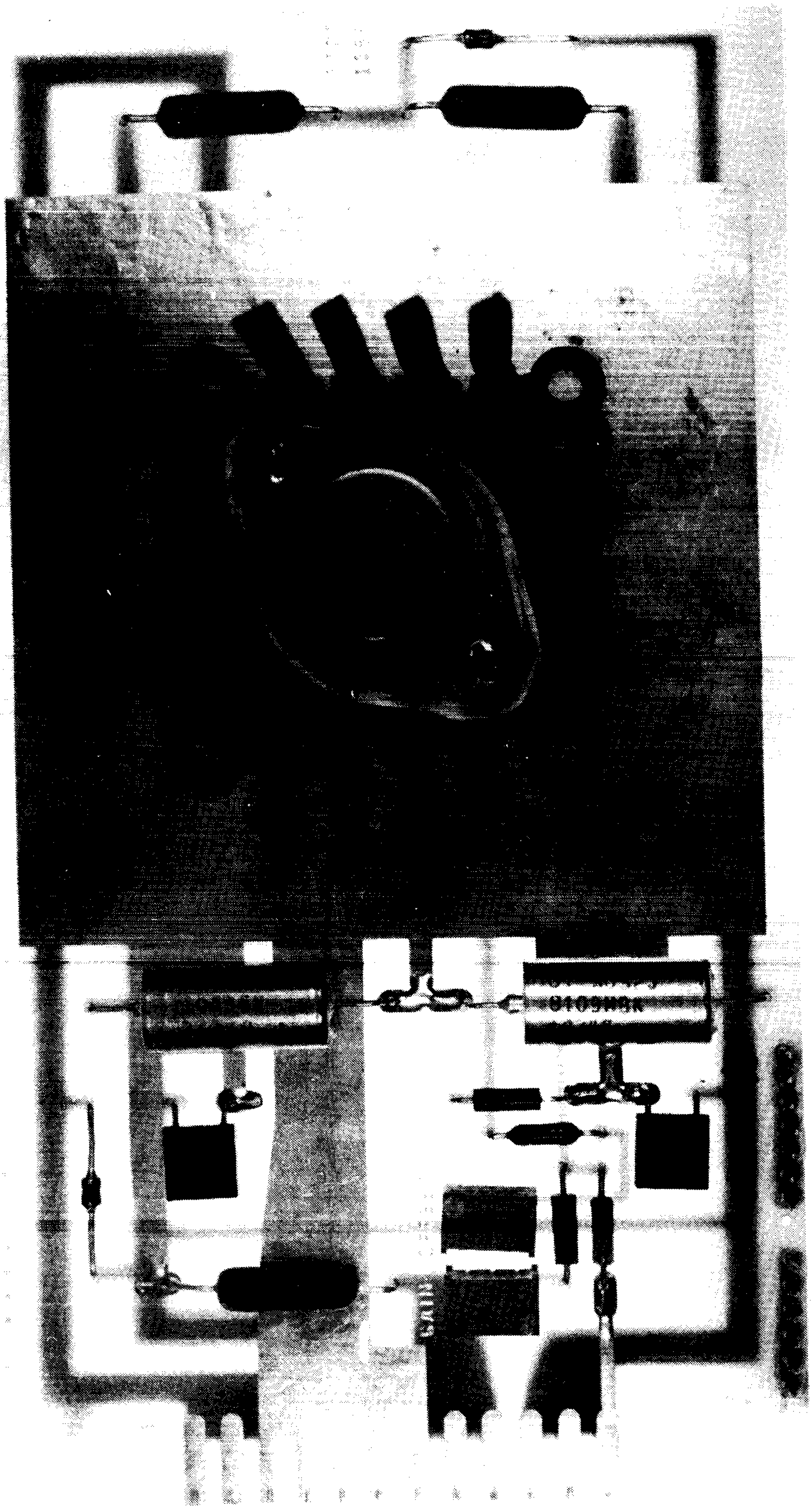
The 8751 has erasable/programmable memory which contains the program that accepts the analog inputs and constructs the output command. The output command controls the position of the proof-mass to produce a force of a prescribed magnitude and phase.

MICROPROCESSOR CONTROLLER BOARD



POWER AMPLIFIER BOARD

The power amplifer board is fairly simple in design because there are few conponents. The main component is the Burr-Brown operational amplifier. The amplifier accepts a ±10 volt input and outputs ±1 ampere.

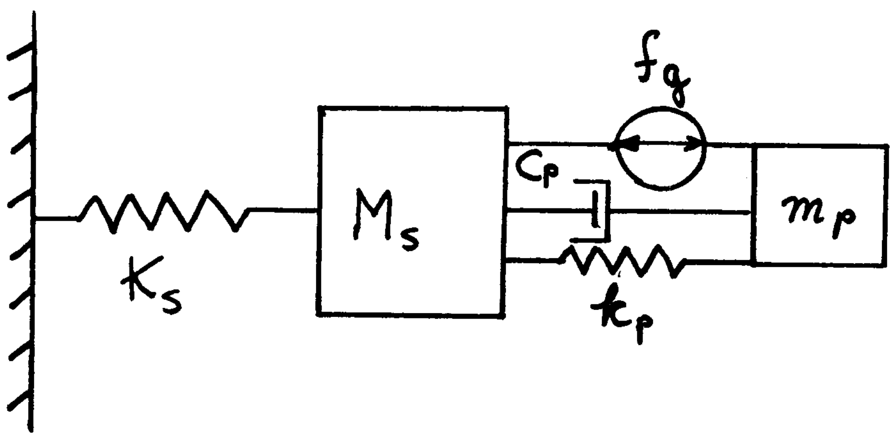


POWER AMPLIFIER BOARD

MODEL OF PROOF MASS ACTUATOR

The model of the actuator is assumed to be single degree-of-freedom dynamic system. The mass of the proof-mass is represented by m_p, the stiffness of the actuator is k_p, the back-emf is denoted by c_p, and the control force is f_g. The other spring and mass simply represent a structural mode to be controlled.

MODEL OF PROOF–MASS ACTUATOR

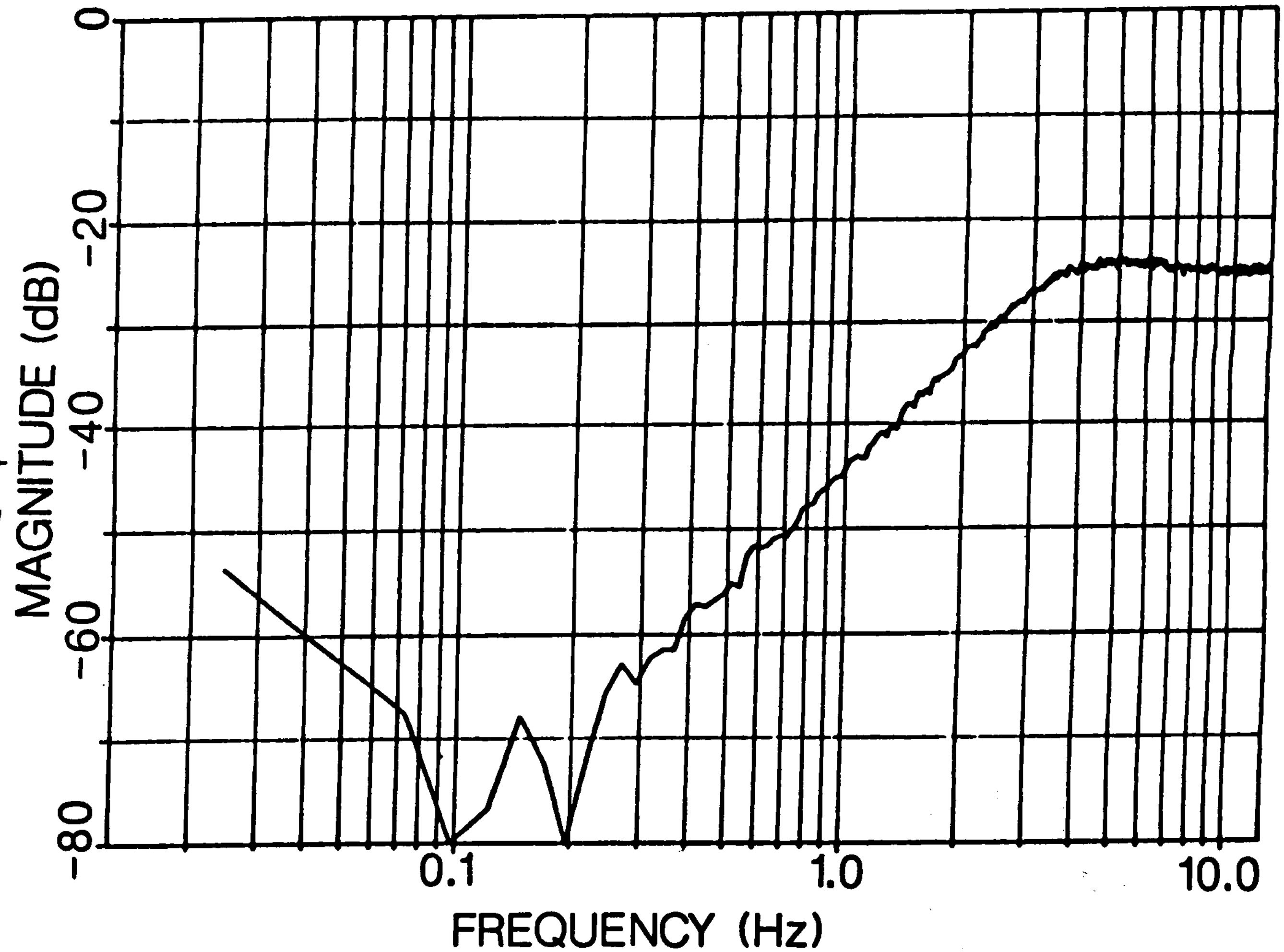


DYNAMIC CHARACTERISTICS

The dynamic characteristics of the proof-mass actuator are described in the transfer function. Here the transfer function is defined as the ratio of the output force to the input voltage as a function frequency. The plot of the magnitude of the transfer function shows that the usable range of the actuator is approximately above 2 Hertz. Beyond 4 Hertz the transfer function is nearly flat.

DYNAMIC CHARACTERISTICS

FORCE / VOLTAGE

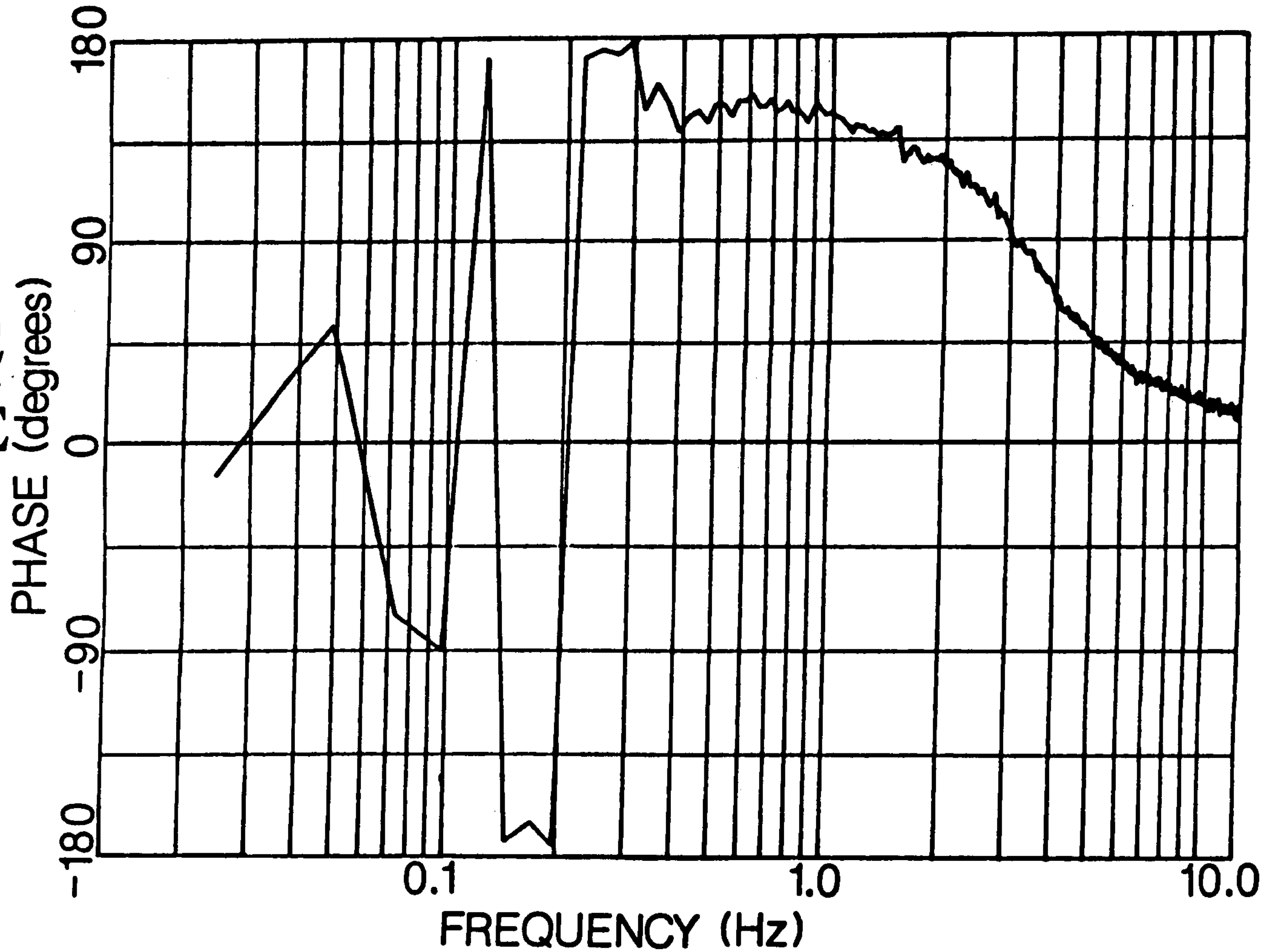


DYNAMIC CHARACTERISTICS - continued

The phase angle of the transfer function is shown is this figure. The erratic response below .4 Hertz is due to the inability of the instrumentation to properly respond to these low frequencies.

DYNAMIC CHARACTERISTICS

FORCE / VOLTAGE



CONCLUSIONS

The major conclusions of the research are that a programmable force actuator has been developed. The actuator has approximately a one pound force capability over the usable frequency range which is above 2 Hertz.

CONCLUSIONS

- PROGRAMMABLE FORCE ACTUATOR DEVELOPED
- ONE POUND CONTROL FORCE CAPABILITY
- LOW FREQUENCY RESPONSE LIMIT APPROXIMATELY 2 HERTZ
- NEARLY FLAT RESPONSE FROM 2 HERTZ TO 1000 AND ABOVE