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REDUCTION OF ELECTRICAL NOISE AND CROSSTALK IN GUIDANCE SYSTEM COMPONENTS

SEPTEMBER PROGRESS REPORT

15 October 1965

Contract NAS8-20118

Prepared for George C. Marshall Space Flight Center
Huntsville, Alabama

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FOREWORD

This document contains a report of progress for the study contract "Reduction of Electrical Noise and Crosstalk in Guidance System Components" covering the calendar month of September 1965. The report was prepared under Contract NAS8-20118 for the George C. Marshall Space Flight Center, Huntsville, Alabama.

The effort has, as its objective, recommendations for reduction of crosstalk and improvement of the signal-to-noise ratio in the ST-124-M stabilized platform and its associated electronics.

NASA/MSFC Technical Supervisors for the contract are Messrs. Owen Rowe and Dave Harper.

WORK ACCOMPLISHED

Cognizant NASA Astrionics Laboratory personnel were briefed on the progress of the servo loop investigation. Four servo loop modules

- Buffer amplifier-detector,
- Bendix servo amplifier,
- Emerson servo amplifier, and
- Power amplifier

were inspected for physical and electrical layout characteristics. The signal flow and decoupling parameters were given particular attention.

The discussion section in this report elaborates on the findings of the servo electronics investigation.

DISCUSSION

The gyro and accelerometer servo loops are similar in many respects. Essentially, the lead networks, decoupling and amplifier gain are the only differences. Therefore, the basic configuration of the two circuits will be the same with different component values. In view of the similarity of the circuits, the analysis of the gyro loop will apply to the accelerometer loop.

The preamplifier is physically located on the gyro header which enables amplifying the error signal before it is subjected to the noise environment of the platform. The preamplifier's output is wired via a shielded-twisted pair wire to a transformer input of the buffer amplifier. The shield and signal common are connected to the dc common which is technically sound. This wiring and shielding scheme maintain the shield and the signal common very close to the ground plane potential. Therefore, the common mode rejection of the buffer amplifier should be relatively high.

The buffer amplifier input transformer's Faraday shield would be more effective if it were connected as illustrated in Figure 1. The purpose

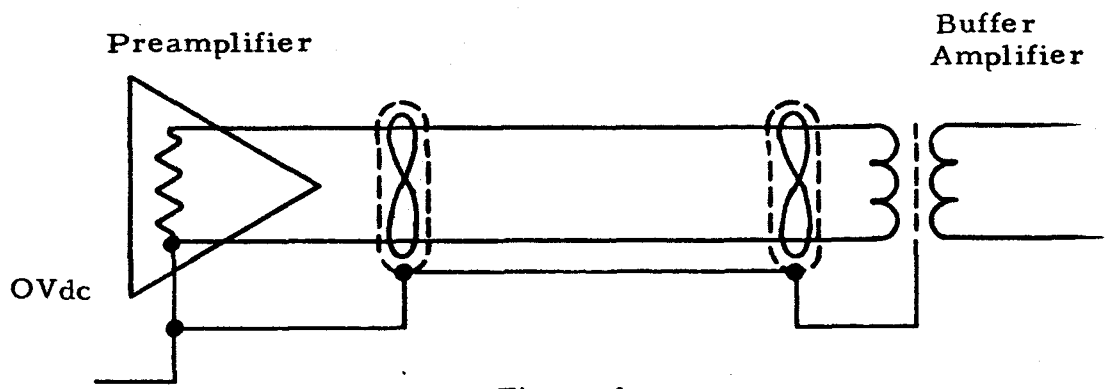

Figure 1

of the Faraday shield is to reduce the capacitive coupling between the transformer's primary and secondary windings. The noise, coupled electrostatically, is shunted via the shield to primary capacitance and a low impedance connection to the zero potential ground. The lower potential ground relative to the signal would be through the shield to the signal ground of the preamplifier. Hence, complete electrostatic shielding and dc isolation between the two circuits exists.

The Faraday shields in the transformers of the detectors are connected appropriately to the signal common in the buffer amplifier-detector module. Therefore, dc and electrostatic isolation is present at the input and the output of the buffer amplifier-detector module. Figure 2 shows the signal flow grounding scheme used in the buffer amplifier-detector module.

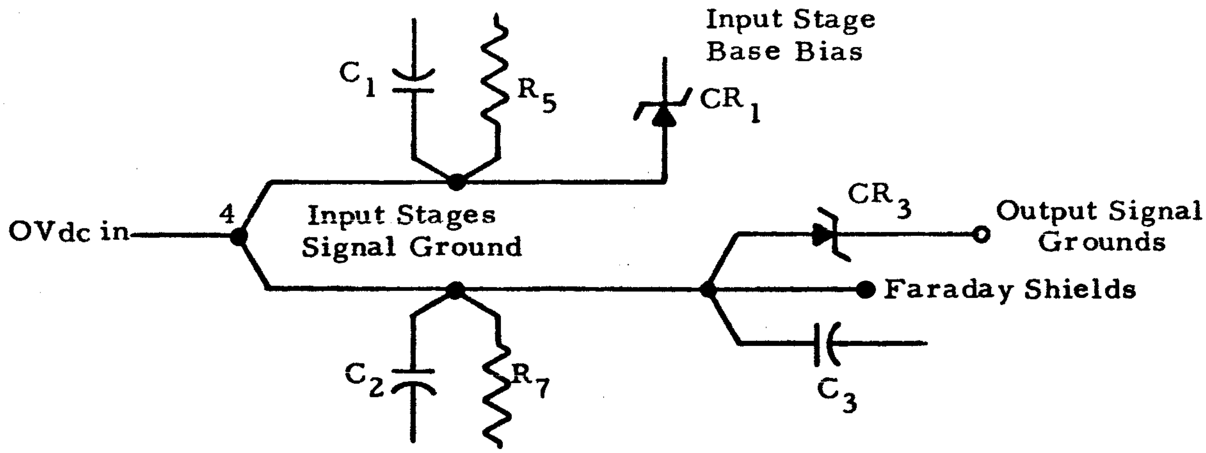

Figure 2

Presently, no shielding is used on the servo signal lines in the platform and possibly, no transposition schemes are used. Also, the shields in cable 603W106 are common which permits crosstalk (see Figure 3) by allowing circulating currents in the cable shields. A blanket

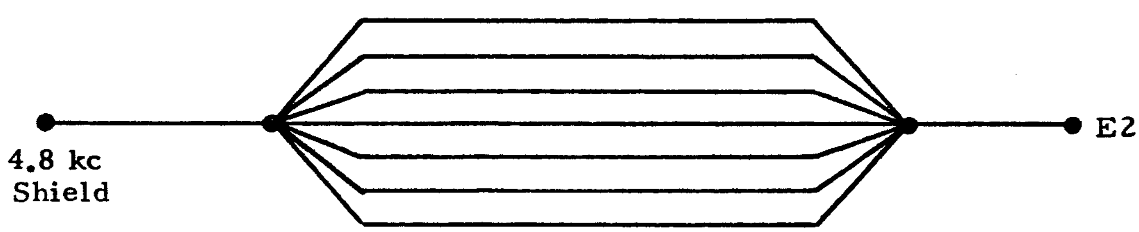

Figure 3

shield scheme for the servo signal lines is not practical because of the inadequate number of spare pins in connector J2. Therefore, the only solution will be to isolate (float) the platform end shields for the servo signal lines and ensure that insulated shields are used. The recommended measure will permit shielding the electrostatic field, the most predominant interference, without major modifications.

The servo amplifier manufactured by Emerson Electric revealed some minor discrepancies in signal flow ground paths. Figure 4 illustrates the physical signal flow routing while Figure 5 presents the intended path (reference Emerson print 528860, code number 20418). Figure 5 is a technically correct grounding scheme. Figure 6 contains the Bendix ground layout for the servo amplifier. The plan follows the prescribed electrical layout and presents a minimum interference configuration. Minimum interference due to common impedance is present when the higher level circuits are closer to the dc power supply. In essence, low level circuits should not form a junction with a signal common buss conducting current greater than the current flow of the low level circuit.

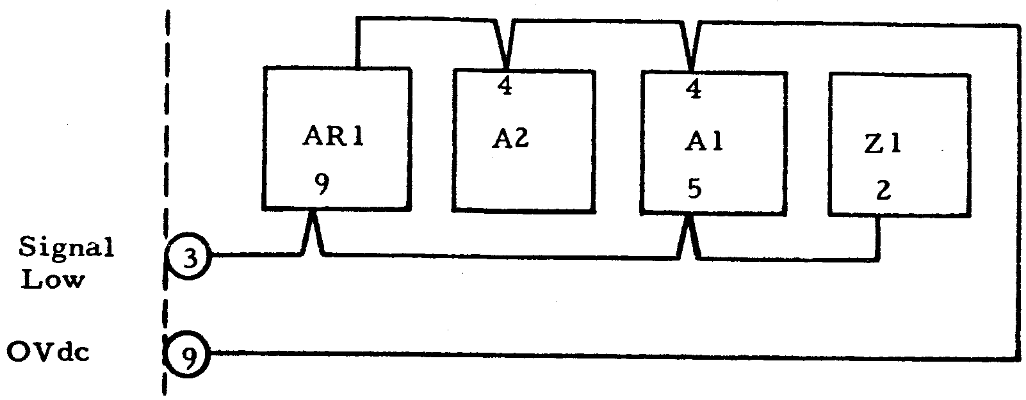

Figure 4

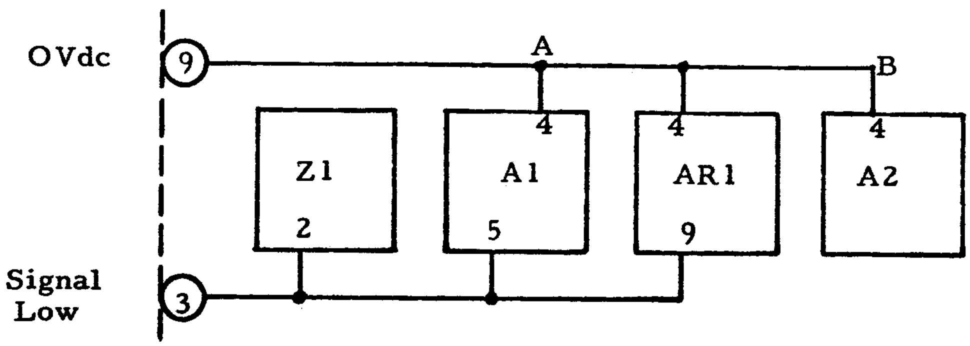

Figure 5

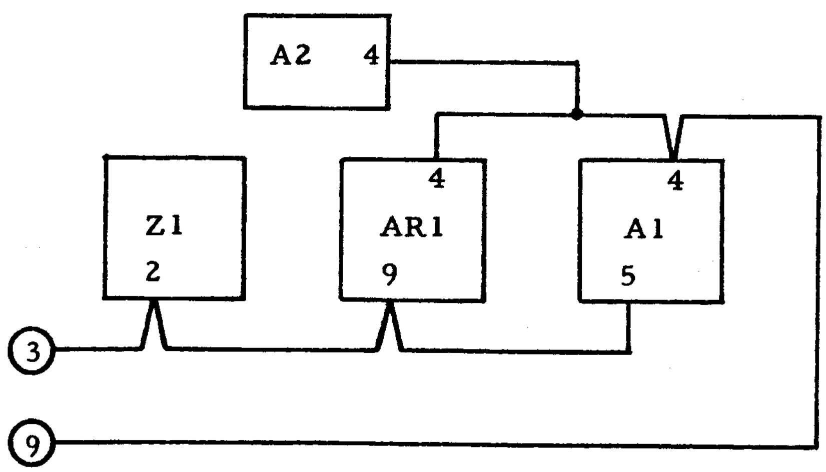

Figure 6

The layout of the power amplifier presented no discrepancies. The low level and the high level portions of the signal ground of the circuit are routed independently to the connector pin that is used for the dc common.

The decoupling used throughout the servo loop appears compatible with the inner stage filtering. For instance, the platform detector output filter's Bode′ plot presents a curve that is down 3 dB at approximately 1 kHz and the decoupling in the buffer has a roll of frequency of approximately 1 kHz. Similar conditions were found in the servo amplifier and the power amplifier. Magnetic shielding should be used on the open frame transformers of the servo loops. Specifically, the two transformers in the buffer amplifier-detector module are in very close proximity and the cores are closely aligned which is highly susceptible to cross-coupling of flux leakage.

This completes the summary of the problem areas discovered in the servo loops. The similarity between the two loops, accelerometer and gyros, requires only one investigation to present a composite picture for both circuits.

PROGRAM PLAN

A revised summary of the program plan and schedule is shown in Table I. Also shown is the predicted manpower assignment throughout this contract period and the progress of each of the tasks. All phases of the program are on schedule. The final report is the only remaining task to be completed.

FUTURE WORK

The material collected and analyzed during the tenure of this contract is being organized into a final report. The remainder of the contract period will be utilized in completing the final report.

TABLE I

PROGRAM PLAN