A DUAL-RANGE RADAR ALTIMETER OF THE EGYPTIAN AIRBORNE GEOPHYSICAL SURVEY SYSTEM

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1. INTRODUCTION

The Nuclear Materials Authority (NMA) is currently conducting airborne radiospectrometric and magnetic survey programs to cover the whole surface of the Egyptian territory within approximately ten years, on a scale of 1:100000. The broad objective of this program is to apply high technology to the implementation of the advanced and reliable airborne geophysical survey system: PDAS-1000 in mineral exploration and environmental monitoring. This application and implementation will permit better and greater operational capabilities as well as increased performance of the geophysical system and hence the survey quality. The proposed program makes use of, tests, modifies, and calibrates the analog input board for the geophysical survey system which was originally designed by Picodas Group Inc., Canada. In this design, which was invented by Scintrex Ltd. Company**, the analog board was designed and calibrated for only one channel for a radar altimeter ranging from zero to 500 ft, which cannot record any data above this flight altitude. Therefore, the objective of this paper is to establish and construct a practical (real) design for another (new) channel that records from 500 to 2500 ft, using a new connection designed at the rear panel of the analog board of the PDAS-1000. Afterwards, modification and calibration of the analog board were carried out. Calibrating the analog inputs requires the adjustment of both the software within the program and the hardware. The software program enabled the survey parameters to be set to the appropriate system specification. The hardware adjustment was conducted *via* the calibration controls located on the rear panel of PDAS-1000. Now, the analog board controls the measured data at the real flight altitude to provide a wide range of data reading.

2. SYSTEM DESIGN

The Egyptian Airborne geophysical survey system (EAGSS) is a microprocessor-based data acquisition (PDAS-1000) system, which can be configured to suit the individual applications. The unit is equipped with a Microsoft Disk Operating System (MS DOS) and is compatible with the IBM PC computer. The PDAS-1000 microprocessor receives signals simultaneously from a large number of sensors including radiospectrometric, magnetic, navigational, temperature, and pressure. Inputs can be in analog, serial digital, or parallel digital forms. The computer performs several functions for which separate, dedicated, sensor electronics were previously required, reducing weight, power consumption and increasing ease of operation.

The PDAS-1000 console is really a robust mainframe, containing a microcomputer, alphagraphics plasma display, program load, and power supplies. Additional electronic circuit boards are added to an easy-to-service mainframe, as required, for duties such as fiducial generation, magnetometer measurements, radiospectrometric measurements, navigation, radar altimeter, barometric, temperature sensor, video or camera flight path recovery system.

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The general block diagram for the PDAS-1000 Egyptian Airborne Geophysical Survey System (EAGSS) is shown in Figure 1.

The location of control of the probe rear panel of the analog board is shown in Figure 2.

The rear panels available for control were X-axis fluxgate, Y-axis fluxgate, Z-axis fluxgate, barometer compensation, radar altimeter, barometer altimeter, and outside air temperature. The sensor complement and the number of dedicated redundant channels for each sensor comprises: inertial instrument, radiospectrometer, barometer compensation, pilot input (pitch, roll and rudder), and elevator secondary actuator [1].

The channels altitude envelope used for the control design is shown in Figure 3.

From Figure 3, it is clear that as the aircraft flight altitude increases from 0 to 500 ft, it follows the linear design, while when it exceeds 500 ft till 2500 ft, it is governed by the nonlinear mathematical design.

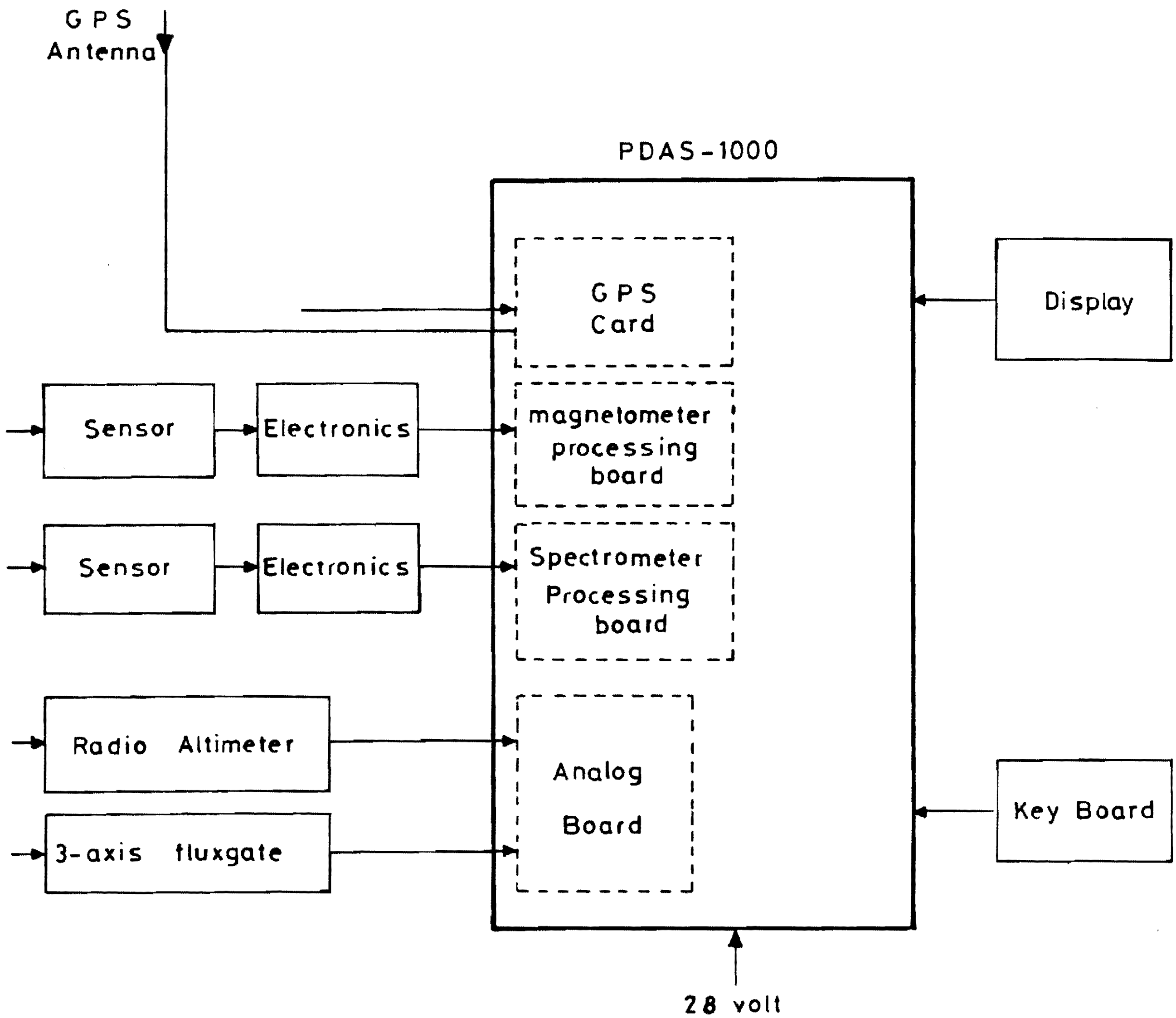

Figure 1. Block diagram for the PDAS-1000 Egyptian Airborne Geophysical Survey System (EAGSS).

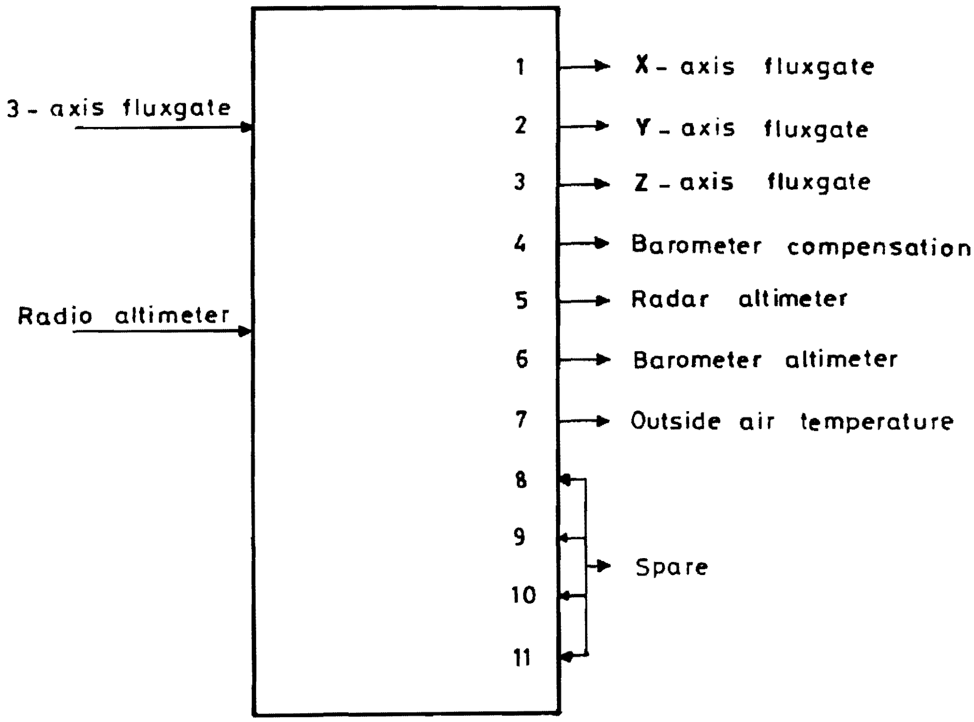

Figure 2. Rear panel of the analog board of the PDAS-1000 of the Egyptian Airborne Geophysical Survey System (EAGSS).

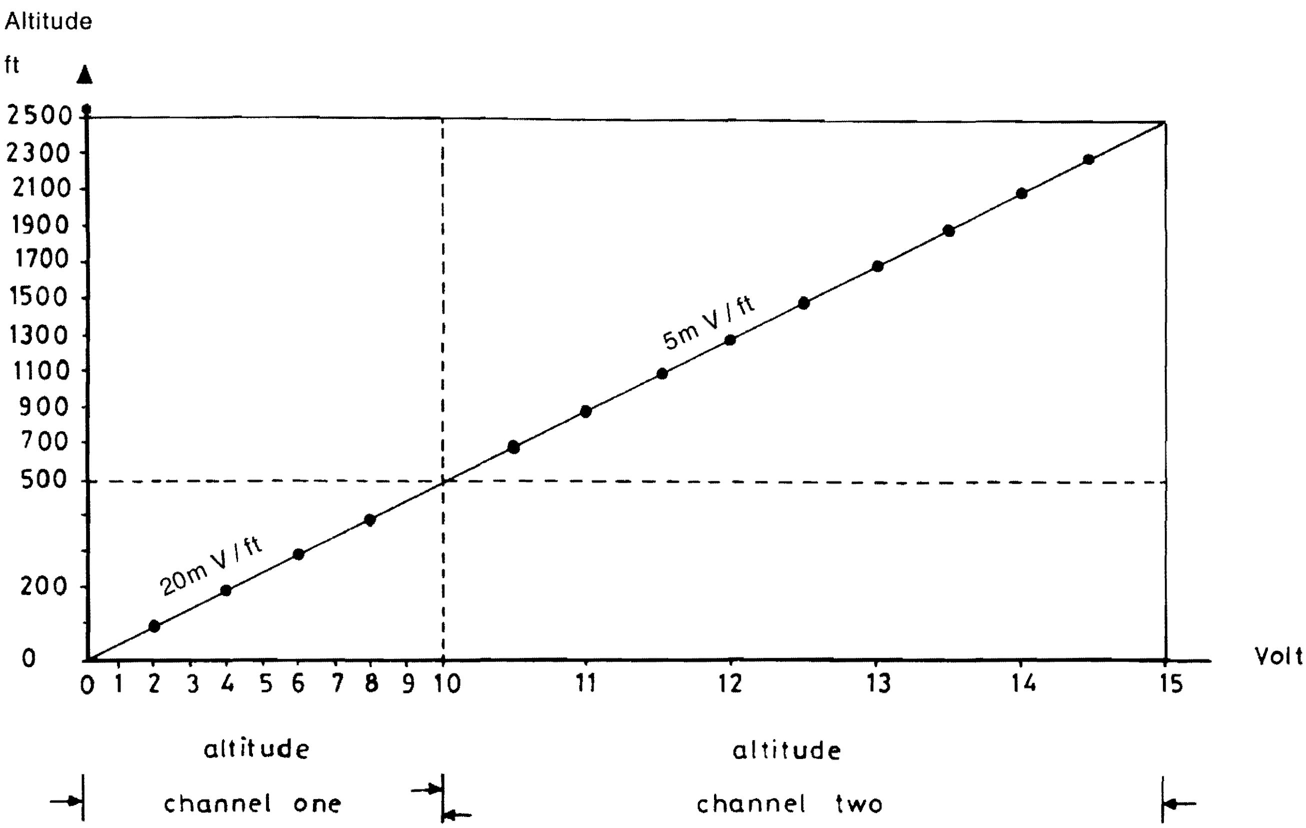

Figure 3. The two channels for altitude recording (0–500 ft and 0–2500 ft) used for the control design of the PDAS-1000 of the EAGSS.

3. APPLICATION OF THE TWO (OLD AND NEW) RANGES OF DRRA OF THE EAGSS IN THE REAL FIELD

In ground surveys, the percentage contribution of cosmic rays relative to ground sources is small and normally neglected. In precise airborne work, the Compton scattering products of cosmic ray interactions must be corrected for [2].

Since it is difficult to maintain a constant flight altitude with respect to the ground terrain, therefore, these variations in ground clearance should be corrected for, to eliminate altitude anomalies on the basis of an experimental air attenuation coefficient for homogeneous infinite plane sources. All the recorded radioactivity data should be reduced to a standard level (either ground level or 400 feet altitude), so that all values can be evaluated as if measured on the same level and hence comparable [3].

Using the determined data of the variation of count-rate with height (Figure 4) over a homogeneous infinite plane source, in the range of 0–700 m, the reduction coefficient P_h for different altitudes (h, in meters) could be evaluated for the flying altitude range (0–200 m) from the equation $P_h = I_{0m} / I_{hm}$ or $P_h = I_{125m} / I_{hm}$ where I_{0m}, I_{125m}, and I_{hm} are the radiometric intensities registered on ground level, at 125 meters above ground and at an altitude h, in meters, above ground, respectively [3].

Figure 5 shows the values of the reduction coefficients (relative count rate P_h) for different survey altitudes calculated from experimental data for an infinite homogeneous non-anomalous plane source [3].

The new DRRA of the new EAGSS installed in the new Egyptian geophysical aircraft (Beechcraft King Air C90A/B) were used to register experimental radiospectrometric data at various altitudes. Real field measurements applying the two (old and new) ranges of the dual-range radar altimeter (DRRA) of the four radiospectrometric channels (*TC, K, eU*, and *eTh*) of the Egyptian Geophysical Airborne Survey System (EAGSS) were carried out over an infinite plane source at Abu-Zeneima Airport, Sinai, Egypt, in 1998. The results are shown in Table 1 and Figures 6 to 9.

The experimental reduction coefficients (P_h) for the different survey altitudes ranging from 0.0 to 450 m were calculated from the real field data recorded at Abu-Zeneima Airport, Sinai, Egypt, in 1998. The results are shown in Table 2 and Figures 10 to 13 for the four radiospectrometric channels (*TC, K, eU,* and *eTh*).

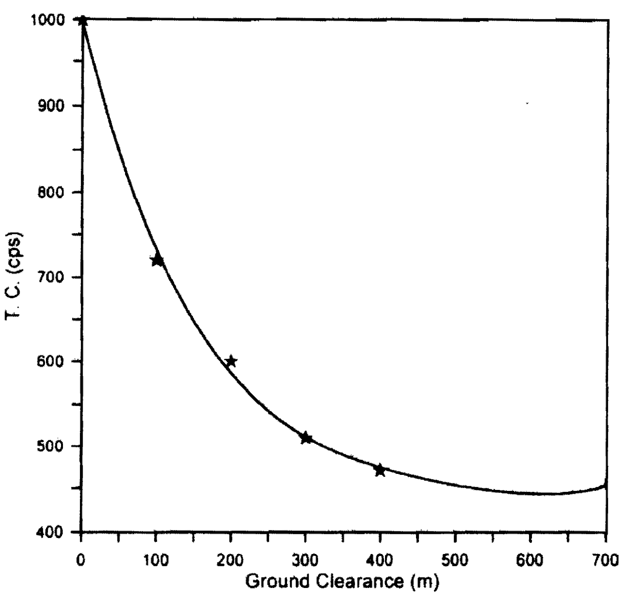

Figure 4. Variation of the radiometric total-count rate (in cps) with ground clearance (in m) over an infinite plane source, Luxor Airport, Egypt [3].

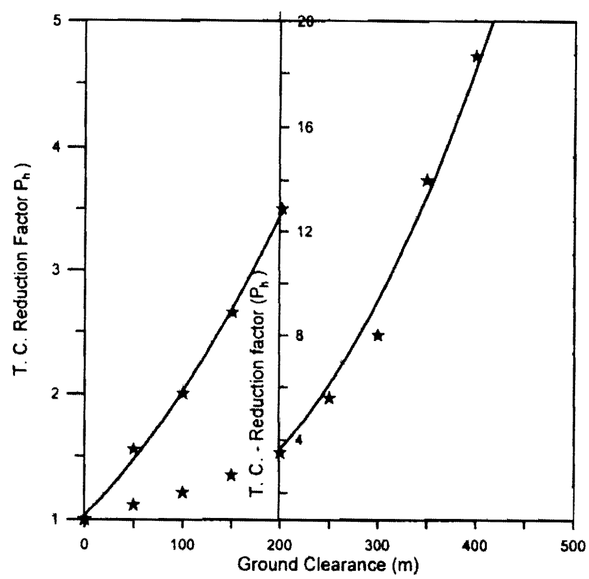

Figure 5. Relationship between the experimental reduction coefficients (P_h) of the gamma rays registered for an infinite plane source and the ground clearance [3].

Table 1. Variation of the Total and Spectral Count Rates of the Four Channels (in cps) With Altitude (*h*, in ft and m), Conducted in 1998, at Abu-Zeneima Airport, Sinai, Egypt.

h		*TC*	*K*	*eU*	*eTh*
ft	m				
159.5	40.61	3556.8	107.5	31.4	36.6
346.4	105.58	2485.1	72.4	22.0	19.6
434.3	132.37	2664.5	75.4	21.1	26.7
503.8	153.55	2024.6	53.8	22.3	14.9
597.1	181.99	1768.0	44.9	17.8	18.7
667.2	203.35	1457.7	41.9	14.1	14.8
722.9	220.33	1223.8	28.4	13.9	13.4
867.5	264.41	996.1	25.0	12.7	8.3
952.2	290.22	832.3	19.6	9.0	9.3
1084.6	330.39	885.0	16.9	8.4	6.9
1191.1	363.03	541.1	11.4	5.7	5.7
1266.5	386.01	513.6	11.8	5.9	3.0

Table 2. Reduction Coefficients (P_h) Computed at Different Altitudes (in ft and m) for the Four Total and Spectral Windows of the EAGSS, for Data Measured in 1998, at Abu-Zeneima Airport, Sinai, Egypt.

h		*TC*	*K*	*eU*	*eTh*
ft	m				
0.00	0.0	1.00	1.00	1.00	1.00
164.45	50.0	1.29	1.27	1.22	1.26
328.90	100.0	1.70	1.66	1.48	1.77
493.35	150.0	2.28	2.37	1.81	2.18
657.80	200.0	3.31	3.26	2.31	2.86
822.25	250.0	4.40	4.66	3.19	4.61
986.70	300.0	7.16	8.24	4.46	7.55
1151.20	350.0	15.42	10.77	6.70	9.22
1315.6	400.0	25.10	28.00	9.57	11.85
1480.1	450.0	40.10	46.66	67.00	16.60

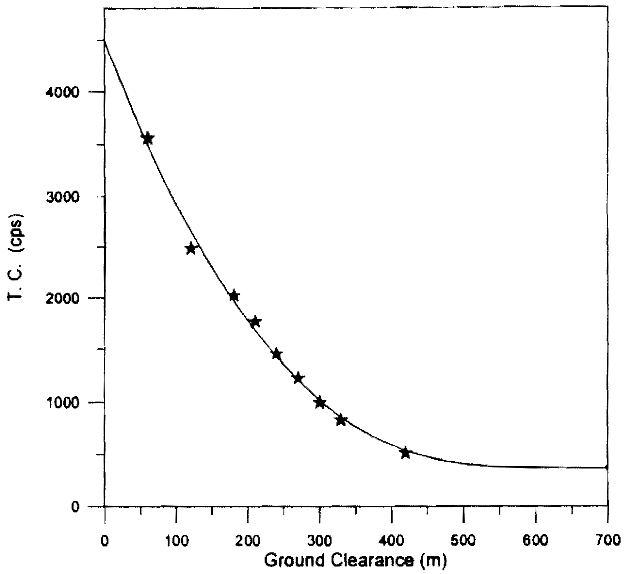

Figure 6. Variation of the T.C. *rate (in cps) with ground clearance (in m) over an infinite plane source, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

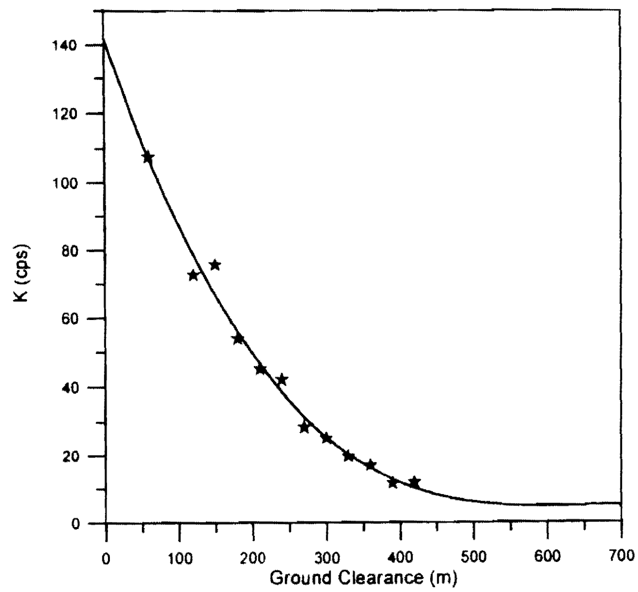

Figure 7. Variation of the K *count rate (in cps) with ground clearance (in m) over an infinite plane source, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

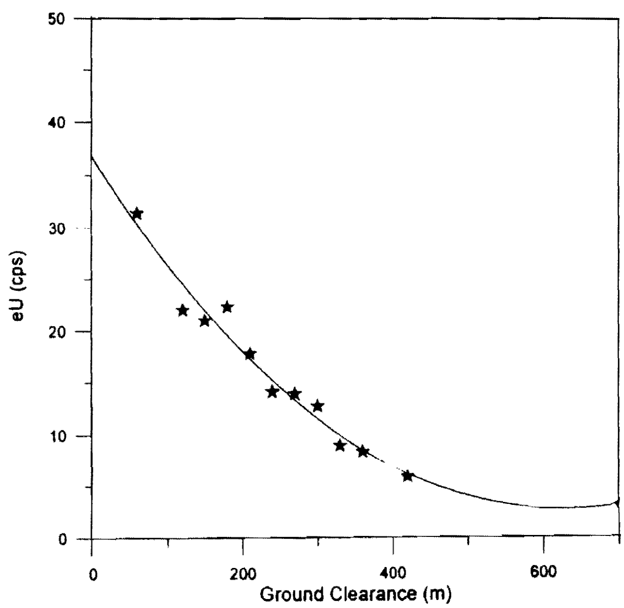

Figure 8. Variation of the eU *count rate (in cps) with ground clearance (in m) over an infinite plane sources, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

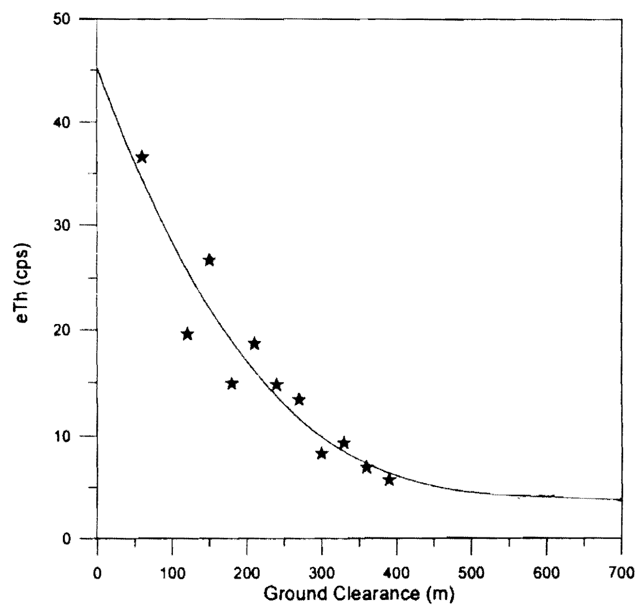

Figure 9. Variation of the eTh *count rate (in cps) with ground clearance (in m) over an infinite plane source, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

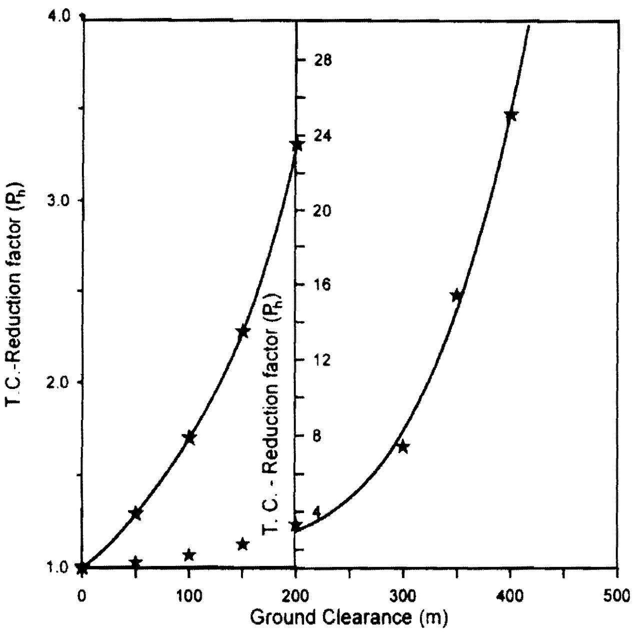

Figure 10. Relationship of the experimental T.C.*-reduction coefficient* (P_h) *of gamma-rays for an infinite plane source and ground clearance, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

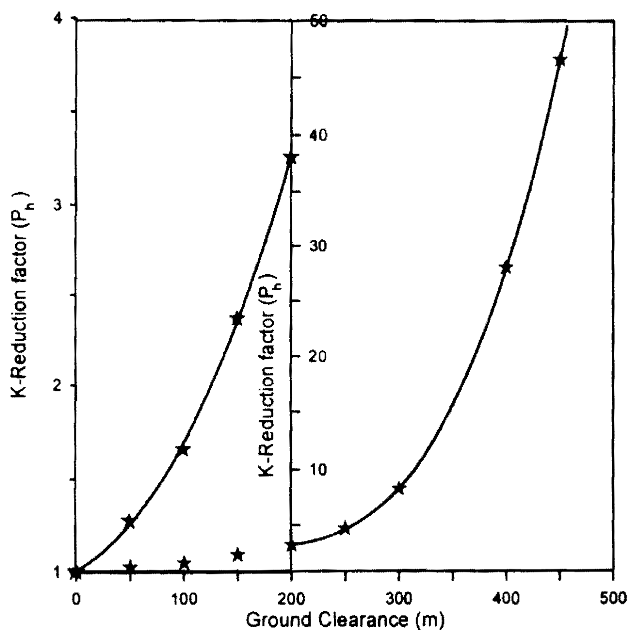

Figure 11. Relationship of the experimental K*-reduction coefficient* (P_h) *of gamma-rays for an infinite plane source and ground clearance, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

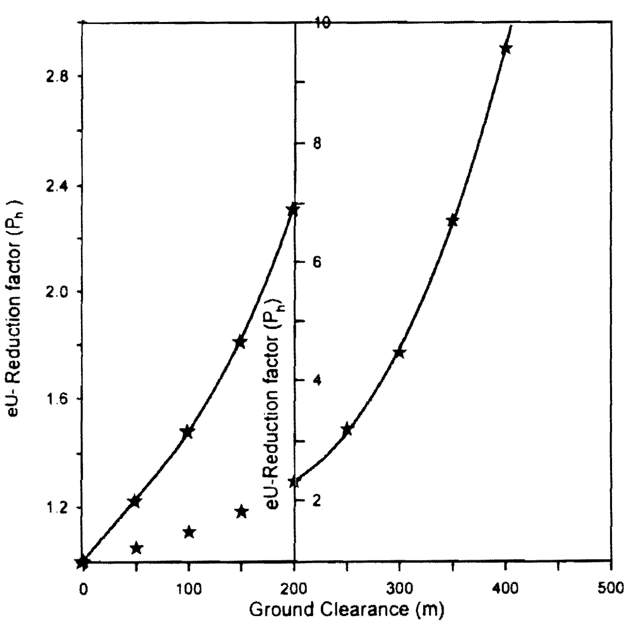

Figure 12. Relationship of the experimental eU*-reduction coefficient* (P_h) *of gamma-rays for an infinite plane source and ground clearance, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

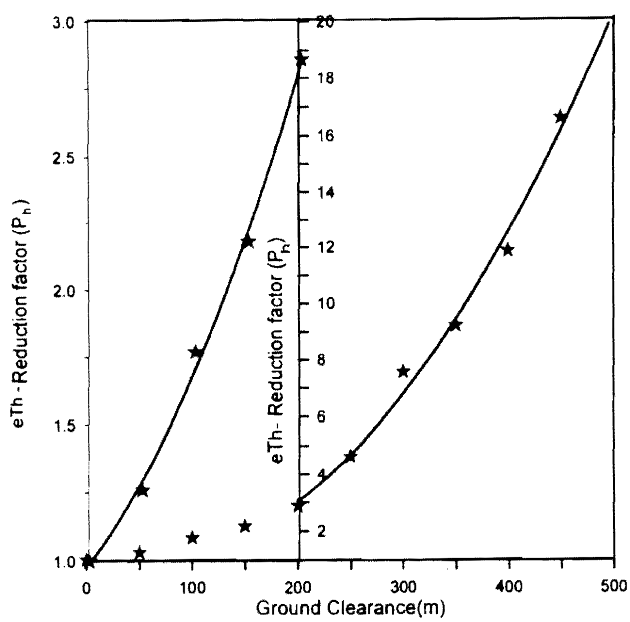

Figure 13. Relationship of the experimental eTh*-reduction coefficient* (P_h) *of gamma-rays for an infinite plane source and ground clearance, Abu-Zeneima Airport, Sinai, Egypt, 1998.*

4. CONTROL STUDY OBJECTIVE

The main objective of the advanced control study is to add a new real altitude channel from the analog board as shown in Figure 14.

The concepts for designing this channel which can lead to a wider range of recording of data (flight altitudes varying from 0 to 2500 ft) must be identified. The most important reason for choosing a wider channel over the original narrower one is that there is always a need to know the real altitude of the aircraft over the rugged areas as well as over the entire survey area and ultimately to correct the aerial radiospectrometric data for altitude changes. To carry out the required modification and then calibration, it is desired to become familiar with selecting and modifying instructions and parameters, as shown in Table 3, channel 0–6 [4] and channel 7 (high radar altimeter) added by the authors, before carrying out the practical design of channels and calibrating the analog board.

To modify the input signal channels, as shown in Table 3, some of the PDAS-1000 conversion factors (0, 1, and 2, Table 3) were fixed and the remaining ones were modified. The PDAS-1000 has an external offset parameter and an internal offset one for the analog board. The internal offset value is automatically calculated by the PDAS-1000 software, while the

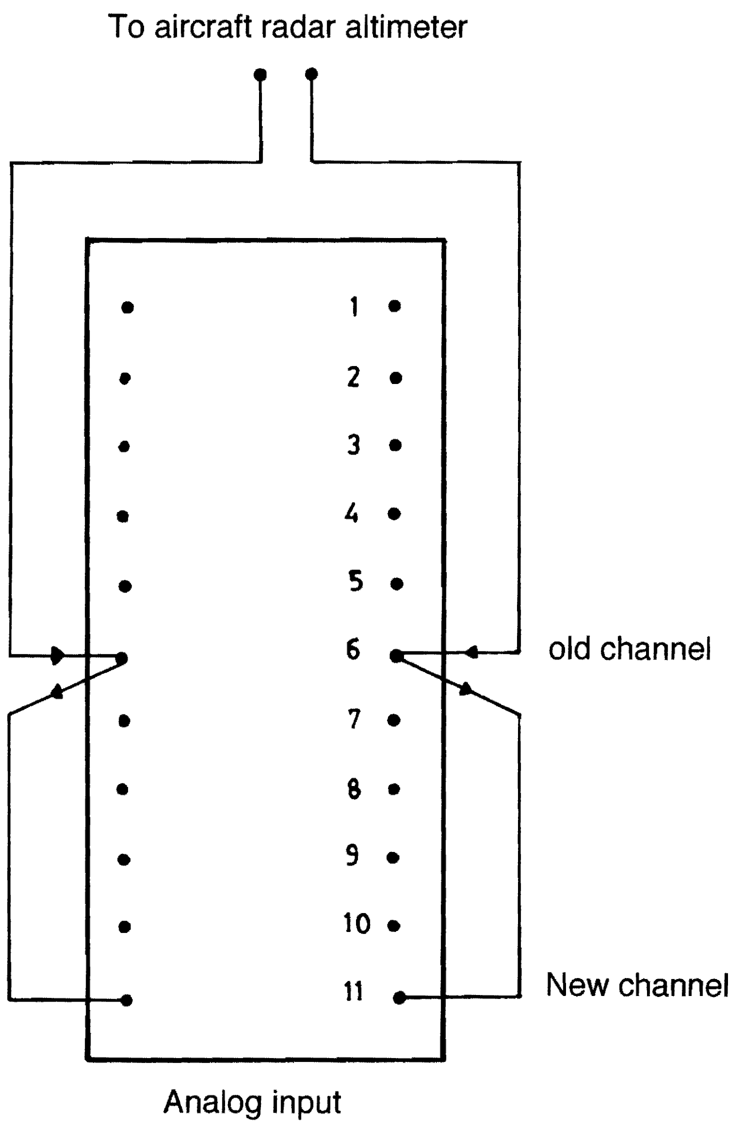

Figure 14. Rear panel of the analog board of the PDAS-1000 of the EAGSS, with the new altitude channel recording from 0.0–2500 ft (0–762.0 m).

Table 3. The Analog Board Calibration of the DRRA of the EAGSS.

Channel	Name	Count	Volt	Unit	Full-scale	Factor	Conversion	Offset
0	*X*-Fluxgate	30000	6	mV	6000	1000	0.200	0.0
1	*Y*-Fluxgate	30000	6	mV	6000	1000	0.2 00	0.0
2	*Z*-Fluxgate	30000	6	mV	6000	1000	0.200	0.0
3	Baro. Comp.	30000	10	mV	10000	1000	0.333	0.0
4	Low Rad. Alt.	30000	10	ft	500	50	0.017	–20.0
5	Baro. Alt.	30000	10	m	1000	1000	0.333	250.0
6	Out Temp.	30000	5	°C	50	10	0.001	0.0
7	High Rad. Alt.	30000	5	ft	2500	16.67	0.083	0.0

external device offsets were determined by the authors. To determine the external device offset reading, the analog device is set to zero. If the PDAS-1000 does not show zero, therefore, the external device output has an offset voltage. This offset reading can be compensated with the offset value. The offset value can be described as a subtracting/adding coefficient, for example: An analog input high radar altimeter probe has an output –1 V at 0.0 ft and +5.0 V at 100 ft. The offset value could be set to +1.0 V so that 0.0 V equals 0.0 ft.

5. CALIBRATION STEPS

1. The socket of the analog inputs is removed and the inputs are replaced with a shorting plug. This will change the analog offsets used by the software program and may affect the D.C. offsets of all analog channels.
2. If all the channels cycles are complete, go to the next step.
3. The +10 volts is applied to the first three analog inputs.
4. The first three channels are checked and must have the following: counts = 30 000 and values 1000 nT. If these values are not accurate, then the calibration controls (potentiometers) on the rear panel must be adjusted until they reflect the desired values.
5. These steps must be repeated for all of the channels until completion of the calibration procedure.

6. CONCLUSIONS

A design for a new channel of the analog board is presented for the PDAS-1000 of the EAGSS, to record flight altitude data up to 2500 ft. In addition, modification and calibration of all the channels of the analog board were carried out.

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