

3 RADIO ALTIMETER

3.1 Introduction

The purpose of the **Radio Altimeter (RA)** is to measure the absolute height of the aircraft above the terrain. This is accomplished by transmitting a signal to the ground, see Fig 5AI 3.1, and processing the received signal into analog voltage proportional to the height. This analog voltage is used to position a pointer on an indicator for a visual indication of altitude.

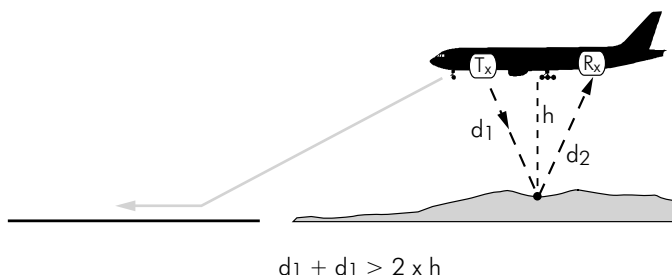


Figure: 5AI 3.1

Using **F**requency **M**odulated **C**ontinuous **W**ave techniques (**FMCW**), radio altimeters provide a continuous indication of height above the surface immediately below the aircraft, up to a maximum of 5,000 ft, with 2500 ft as the most common range. They are particularly suited to low altitude terrain clearance measurement and for provision of height data to GPWS and Autoland (ILS) equipment. Although the antenna of the RA sits at the bottom of the fuselage, an electronic compensation is made so on most larger aircraft the **height (h) is calculated from the lowest wheel.**

The radio altimeter is instantaneous and accurate, but **gives no indication of high ground ahead.**

It is not possible, within the frequency allocation (4200-4400 MHz), to change the frequency (FM) indefinitely. On one popular brand of RA the modulation sweeps 100 MHz between the base frequency 4,250 MHz and the upper limit 4,350 MHz - the variation, or modulation, is made as shown at figure 5AI 3.2 .

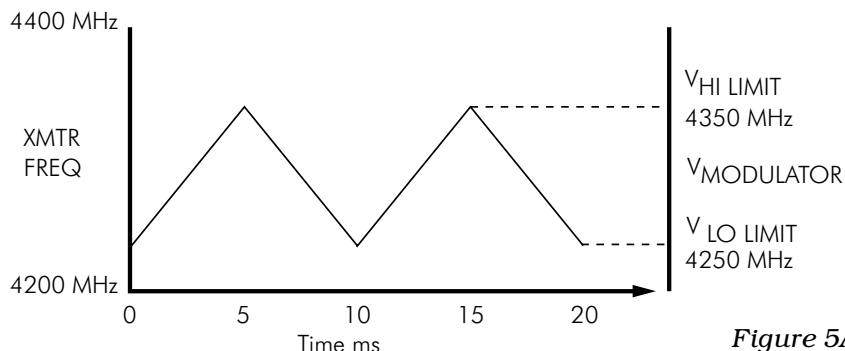


Figure 5AI 3.2

Because the height measurement is absolute, flight over undulating terrain will result in sympathetic variations in the indications of aircraft height on the radio altimeter display.

3.2 Principle of Operation

A radio altimeter will consist of a transmitter/receiver and integral timing device, a transmitter antenna, a receiver antenna and a display of some type, see Fig 5AI 3.3

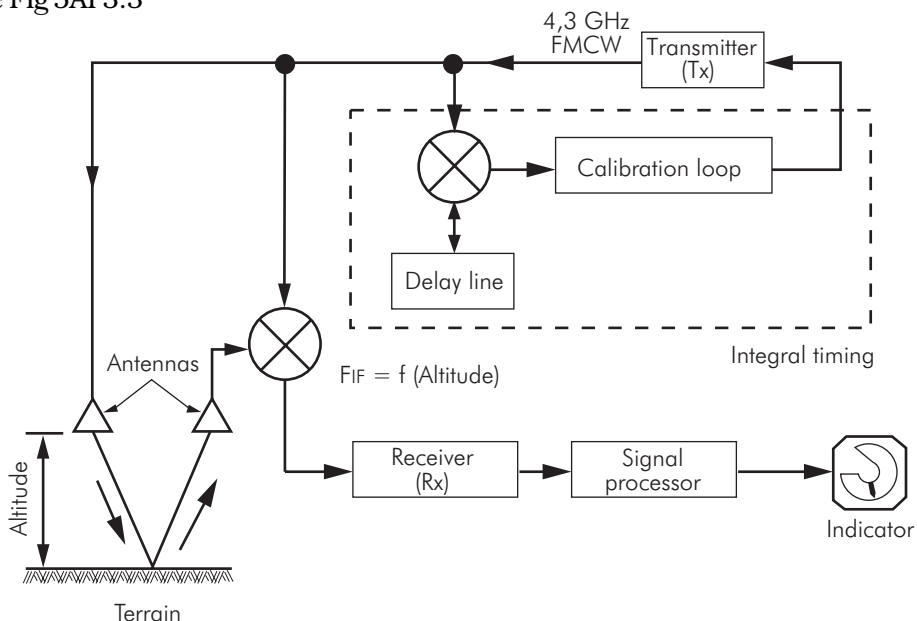


Figure: 5AI 3.3

The elapsed time, from transmission of an electromagnetic signal to reception back at the aircraft after ground reflection, is measured. As long as the path followed by the wave is vertical, down and up, then the elapsed time is a function of aircraft height.

By the time the transmitted signal has been reflected from the terrain and back to the receive antenna the transmitter has shifted to a new frequency; therefore, when the instantaneous transmitted signal is mixed with the delayed received signal, an Intermediate Frequency (IF) is produced. This IF is directly proportional to the time delay for the round trip, as shown at Fig 5AI 3.4.

This variable IF is applied to the receiver where it is amplified and processed to a DC voltage proportional to the incoming IF frequency. The DC analog voltage representative of altitude is used to drive the Indicator and other flight control systems requiring accurate above ground level altitude information.

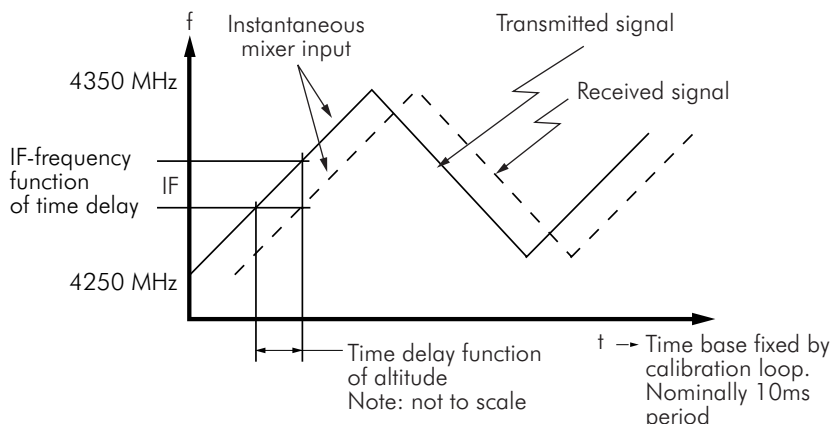


Figure: 5AI 3.4

Throughout the cycle there will be two very short periods when the modulation changes from V_{HI} to V_{LO} and vice-versa; apart from during these short periods, which can be excluded from height calculation, the instantaneous frequency difference is proportional to aircraft height. Sweep-rates are normally in the order of 500 times per second.

It is possible for an aircraft to be at a height such that the returning wave arrives after a complete frequency sweep, and this would give an erroneous height solution. To overcome this ambiguity, the sweep rate is made low, i.e. the time for a sweep is made longer, so that all normal heights within the range of the radio altimeter are covered.

3.3 Display

At Fig 5AI 3.5, two types of radio altimeter display are shown. The displayed maximum altitude (2,500 or 5,000 ft) is obvious from the conventional dial display, but not so apparent from the moving vertical scale presentation. The circular displays are linear up to 500 feet and logarithmic from 500 - 2,500 (or 5,000) feet, making the lower range of heights easier to read more accurately.

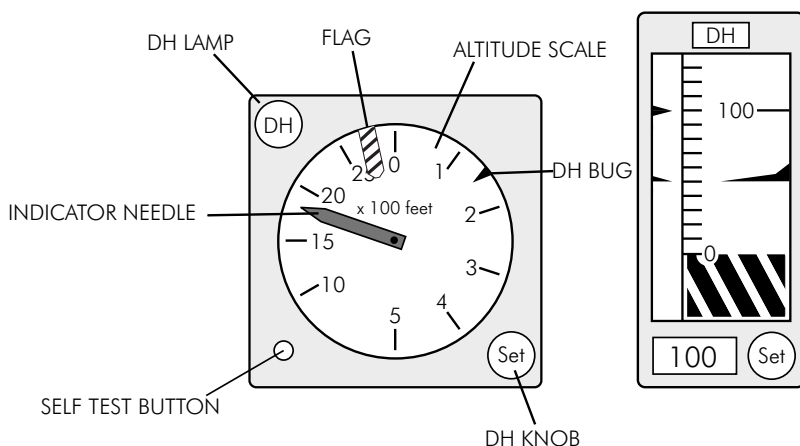


Figure: 5AI 3.5

All radio altimeter displays have a setting control for a decision height, at which point a warning will be given. The height can be set by positioning an outside cursor against the required height on the scale. The setting control will normally double as a PTT (press-to-test) facility which, when engaged, drives the display to a predetermined value - normally 100 feet.

With reference to the left display, an OFF or FAIL flag will be visible when:

- a. The equipment is switched off;
- b. There is a power failure;
- c. A Tx, Rx, or display fault occurs.
- d. The returning signal is too weak;
- e. Signals are reflected from the airframe.

The height pointer is hidden from view behind the mask when:

- a. The equipment is switched off;
- b. A Tx, Rx, or display fault occurs;
- c. The aircraft climbs beyond the equipment height limit

Other Warnings

Both light and/or audio warnings are given for departure from the height limit indicator. Visual warnings may be:

AMBER - above selected height

GREEN - ± 15 feet of selected height

RED - 15 feet below selected height

Where only a single light is fitted, the DH light will flash continuously when the aircraft goes below the set height until the aircraft climbs or until the DH value is set lower.

3.4 Performance

Accuracy

The accuracy of the radio altimeter is expected to be:

0 - 500 feet: ± 2 feet or 2% of height, whichever is the greater.

Above 500 feet: 5 % of height

3.5 Errors

Given that the sweep rate is compatible with the height performance of the installation, the only two errors that might occur are:

a) Leakage - It is necessary to separate the Tx and the Rx antenna on the underside of the aircraft to avoid leakage, i.e. spilling through of side-lobes directly into the

Rx antenna. Placing the antenna a distance apart is generally adequate screening.

b) Mushing - Because the antenna are apart, the closer the aircraft is to the ground, then the Tx antenna, reflection point and Rx antenna form a triangle. It follows that the path travelled by the wave is greater than twice the vertical height between surface and aircraft, as illustrated in figure 5AI 3.1. This causes inaccuracies very close to the ground and is known as “mushing error”.

However, this error is normally remedied by a fixed correction for the particular aircraft, so the height indicated corresponds to the vertical distance from the lower wheels to the ground. When carrying out automatic approach and landing, an important factor is that zero height indication coincides with touch-down.

3.6 Advantages of Radio Altimeters

- Indication of actual (absolute) height is given
- Provides an easy crosscheck with barometric altimeter for terrain clearance
- Provides a warning signal at DH (decision height).

3.7 Outputs

Outputs from the Radio Altimeter can be fed directly or via a data bus to:

- AFCS (for ILS coupling)
- GPNS
- Flight Director
- EFIS
- FMC

SA-IN 3.3

Can you answer these?

- 1 The sustained oscillation in the Ring Laser Gyro (RLG) is initially caused by ...**

 - a) the gas (or plasma) inside the triangular cavity is ionised by the voltage, causing helium atoms to collide with and transfer energy to the neon atoms.
 - b) the spontaneous return of photons to a higher energy level, which in turn produces excited neon atoms.
 - c) the pressure fluctuation in the high pressure mixture of helium and neon gases in the triangular cavity.
 - d) the corner mirrors, which reflect the radiation energy, back to the photons.

- 2 The reason for gently vibrating (dithering) the Ring Laser Gyro | (RLG) is...**

 - a) to sustain the oscillation of the plasma.
 - b) because one laser-beam can “lock-in” to the other at abrupt vertical manoeuvres
 - c) because one laser-beam can “lock-in” to the other at high rates of rotation
 - d) because one laser-beam can “lock-in” to the other at low rates of rotation.

- 3 Which statement below is true when comparing a Ring Laser Gyro (RLG) to a Fibre Optic Gyro (FOG)?**

 - a) The FOG is lighter, cheaper, but has more instrument error
 - b) The FOG is lighter, cheaper, and has less instrument error.
 - c) The fibre optics make the FOG more rugged.
 - d) The RLG and FOG are quite similar in most respects.

- 4 To obtain a reading of zero on a low altitude Radio Altimeter when main landing gear wheels are on the ground, it is necessary to**

 - a) place the antennas on the bottom of the aeroplane.
 - b) change the display scale on short final, in order to have a precise readout.
 - c) account for signal processing time in the unit and apply a correction factor to the reading.

- d) compensate residual altitude due to antennas height above the ground and coaxial cables length.

5 The Decision Height (DH) warning light comes on when an aircraft ...

- a) passes over the outer marker
- b) descends below a pre-set barometric altitude
- c) passes over the ILS inner marker
- d) descends below a pre-set radio altitude

6 The operating frequency of the Radio Altimeter is normally

- a) between 4,250 and 4,350 kHz, FMCW
- b) between 4,250 and 4,350 MHz, FMCW
- c) between 4,250 and 4,350 kHz, CW
- d) between 4,250 and 4,350 MHz, AM

7 The data supplied by a radio altimeter:

- a) indicates the distance between the ground and the aircraft.
- b) is used only by the radio altimeter indicator.
- c) is used by the automatic pilot in the altitude mode.
- d) concerns only the decision height.

8 The modulation method used for Radio Altimeters is called...

- a) Frequency Modulated Calibrated Wave
- b) Frequency Modulated Continuous Wave
- c) Frequency Modulated Asynchronous Wave
- d) Frequency Modulated Amplitude Wave