Radar Altimeter

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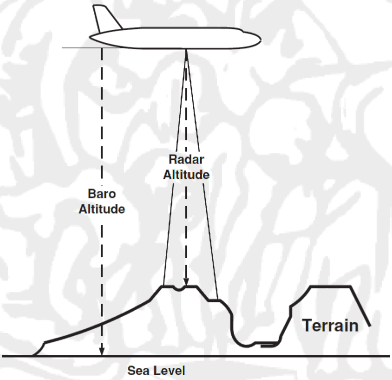
Introduction

The Radar Altimeter (RALT) uses Radio Frequency (RF) transmissions to reflect off the surface of the sea or the ground immediately below the aircraft.

Height

The RALT provides an absolute reading of altitude with regard to the terrain directly beneath the aircraft, which is refereed to as **Radio Altitude (RA)** or **Height**.



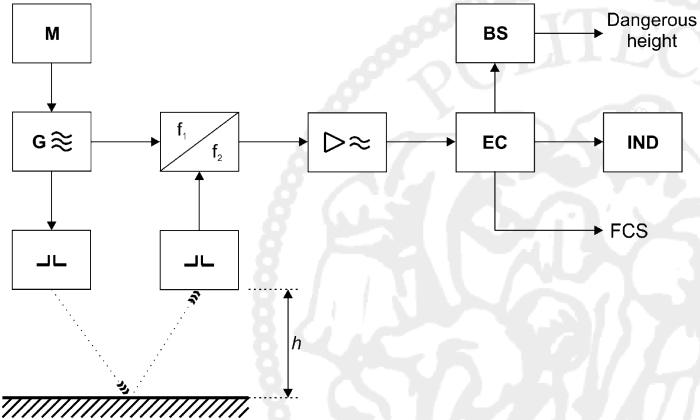
Introduction

The RALT provides an accurate measurement of the height of the aircraft above the ground up to a maximum of generally 5000 ft, though for many RALTs used on commercial aircraft the limit is 2500 ft.

In addition to providing continuous information about clearance above terrain when the aircraft is close to the ground, the RALT provides outputs for other on-board systems, namely:

- Autopilot, during approach and autoland phases.
- Enhanced Ground Proximity Warning System (EGPWS)
- Flight Management Computer (FMC)
- Electronic Flight Instrumentation System (EFIS) Primary Flight Display (PFD)

Block diagram



M=Modulator, G=Generator, EC=Evaluation Circuit,
BS=Block of Signalisation, IND=Indication to the Pilot

Signal

Generally, RALTs do not use pulsed signals.
The reason for this is that with a pulsed radar system it can be very difficult to accurately measure the relatively short distances involved in RALT application.

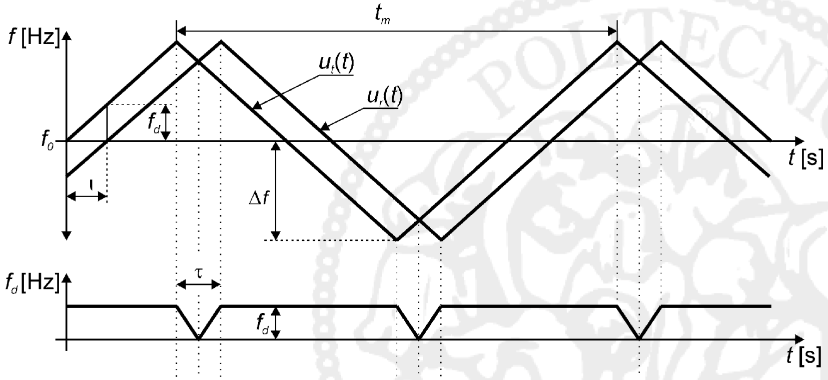
Therefore, a Continuous Wave (CW) signal is used.

Most RALTs use a triangular Frequency Modulated Continuous Wave (FMCW) technique on the transmitted signal as shown in figure next slide, where for an aircraft at an altitude h the propagation delay τ is given by

$$\tau = \frac{2\,h}{c} \tag{1}$$

where, as usual, c is the speed of light in vacuum.

Modulated Signal Characteristics



FMCW transmitted [$u_t(t)$] and received [$u_r(t)$] signal

Signal processing

In the period t_m the transmitted signal frequency is *deviated* (shifted) from the nominal value f_0 by a $\pm\Delta f$ offset.

The slope k_m of the triangular wave signal is determined by:

$$k_m = \frac{2\,\Delta f}{\frac{t_m}{2}} = 4\,\frac{\Delta f}{t_m} \tag{2}$$

At a particular time I, the frequency difference f_d between the transmitted signal and the received signal can be measured.

The latter is proportional to τ:

$$f_d = k_m\,\tau \tag{3}$$

Signal processing

Remembering (1) it can be written:

$$f_d = k_m \, \frac{2\,h}{c} \tag{4}$$

Height h can therefore be computed from (4) as:

$$h = \frac{c}{2} \, \frac{f_d}{k_m} \tag{5}$$

RF signal parameters

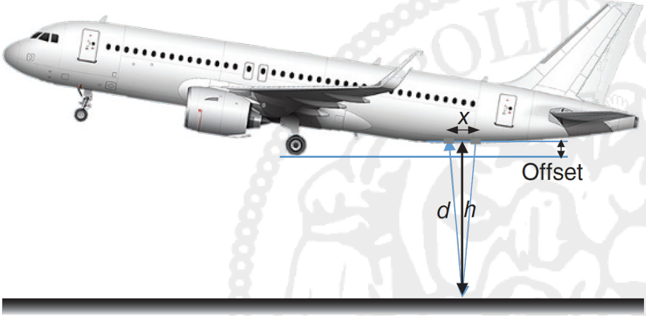
Careful attention must be paid in the determination of the RF signal parameters t_m, Δf, since they have a great impact on the system performance and limitations.

Real-world Radar Altimeters

Here are the typical values for RALTs in use on board A/C:

- Frequency is standardised in C band, and specifically 4300 MHz
- Modulation deviation Δf is 50 MHz
- Modulation frequency is in the order of 100 kHz
- Transmitted power in in the order of hundreds of mW to a few W
- Dual antenna (TX and RX) is generally used, but signle-antenna solutions are available on the market
- Output measurement characteristics:
  - Update rate: tens of Hz (e.g. 50 Hz)
  - Latency: tens of ms (e.g. < 50 ms)
  - Accuracy: ± 1 ft. $+ 1\%$ of Altitude

Measurement Offset (A/C)



An offset is subtracted from the measure in order to read **zero** when the Main Landing Gear (MLG) touches the runaway with:

- A/C configured for landing
- A/C at the flare attitude

Measurement Offset (R/C)

Antennas are generally installed on tail boom on rotorcraft

Commercial products

Dual antenna solution

Single antenna solution

Cockpit Instrument

- Indicator scale is generally not linear, but expanded in the low height range
- Provision for Decision Height (DH) management
  - Setting knob
  - Indicator bug on outer part of scale
  - Blinking light
- Test button

RA representation on EFIS PFD

- RA appears when needed just below the Artificial Horizon

5G Interference

The International Telecommunications Union (ITU) recently approved the use of a spectrum in the lower C Band (3.7-3.98 Ghz) in support of 5G mobile service throughout the World.

In practice, this means that the spectrum, previously reserved for low power applications, will now be available to the telecommunications industry for high power transmissions.

5G Interference

5G high power transmissions have been shown to affect the ability of RALTs to accurately provide altitude measurement, a parameter which is critical to aviation for safe approach and landing operations. As such, many of the RALTs currently fielded by operators today may experience performance degradations and incorrect altitude readings.

List of Acronyms

CW	Continuous Wave
DH	Decision Height
EFIS	Electronic Flight Instrumentation System
EGPWS	Enhanced Ground Proximity Warning System
FMC	Flight Management Computer
FMCW	Frequency Modulated Continuous Wave
ITU	International Telecommunications Union
MLG	Main Landing Gear
PFD	Primary Flight Display
RA	Radio Altitude
RALT	Radar Altimeter
RF	Radio Frequency