Study Area:	Ground Avionics Engineering
Phase I:	Basic ATSEP Course
Stream:	Basic Principles of Distance Measuring Equipment, DME
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Objectives

1. State the purpose of DME
2. State the principle of DME
3. Explain the principle of operation of DME
4. Determine the slant distance
5. Describe signals used in DME
6. Discuss how overload is controlled
7. Discuss how echo and multipath errors are controlled
8. Outline the monitored parameters of DME

Introduction

Navaids:

- Radio communication systems are used to provide navigation guidance to flights.
- Navaids include NDB, DME, VOR, ILS and GNSS.

Previous lessons:

- Introduction to radio navigation
- Principles of NDB

This lesson:

- Introduction to basic principles of DME

Meaning of DME

DME
Distance Measuring Equipment

i.e.
Equipment that measures distance

DME

State the Purpose of DME

Main Purpose

To provide **distance** information between a flying aircraft and a DME ground station

Minor purposes

- provide **time** estimate to the DME station
- calculate **speed** of aircraft

Feedback

1. The DME is a radio navigation system that provides information pertaining to distance from:

A. DME ground station to the airport

B. Flying aircraft to ATC control tower

C. DME ground station to the flying aircraft

State the Principle of DME

DME principle is based on derivation of distance using time and speed of an electromagnetic wave

$$\boldsymbol{distance = time\ x\ speed}$$

$$speed = 3\ x\ 10^{8}\ \mathrm{m/s}$$

Feedback

The principle of DME is based on:

A. Calculation of distance using time and speed of the aircraft
B. Calculation of distance using time and speed of RF waves
C. Calculation of distance using time and speed of sound waves

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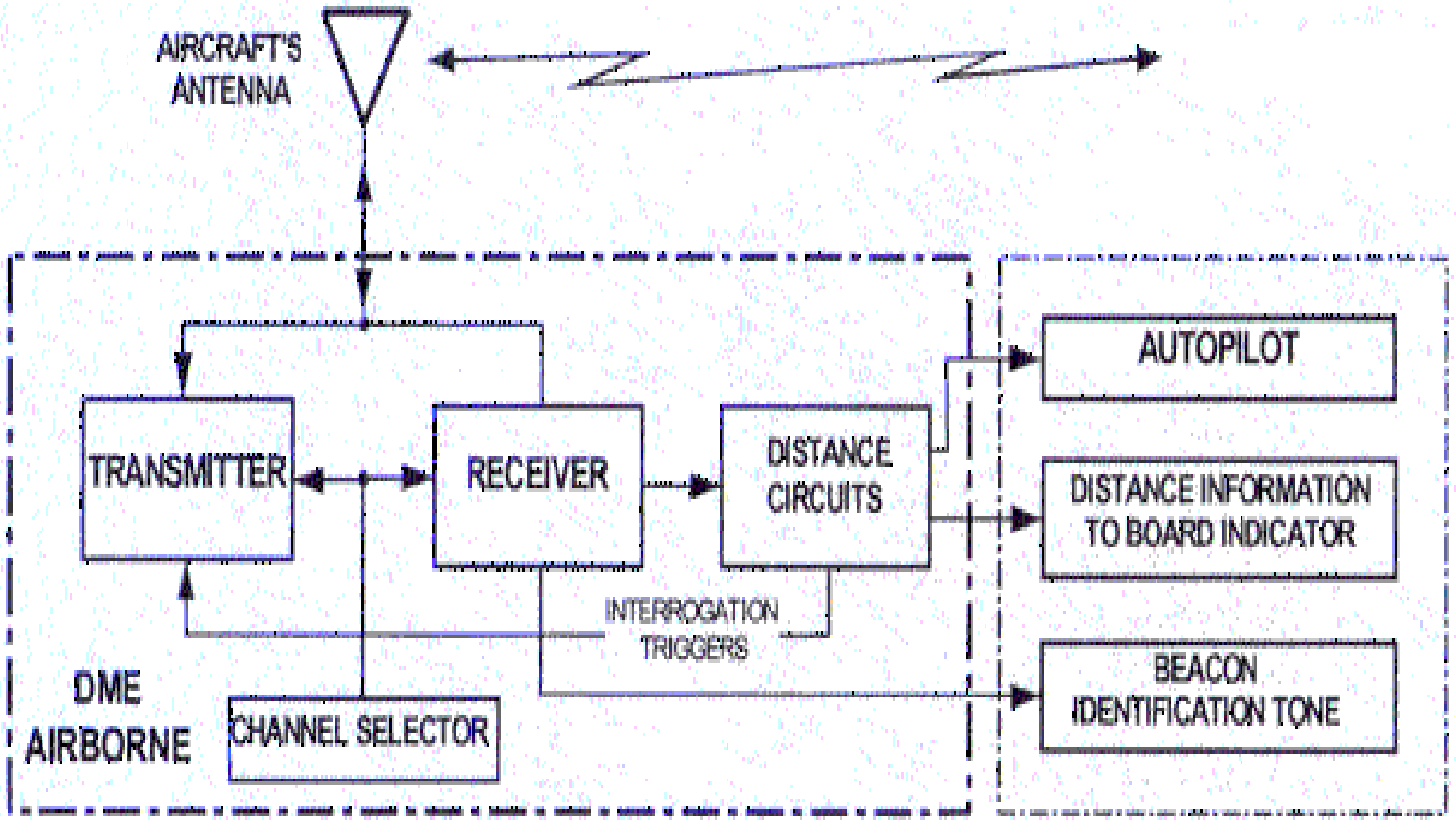
Simplified DME Airborne Instrument



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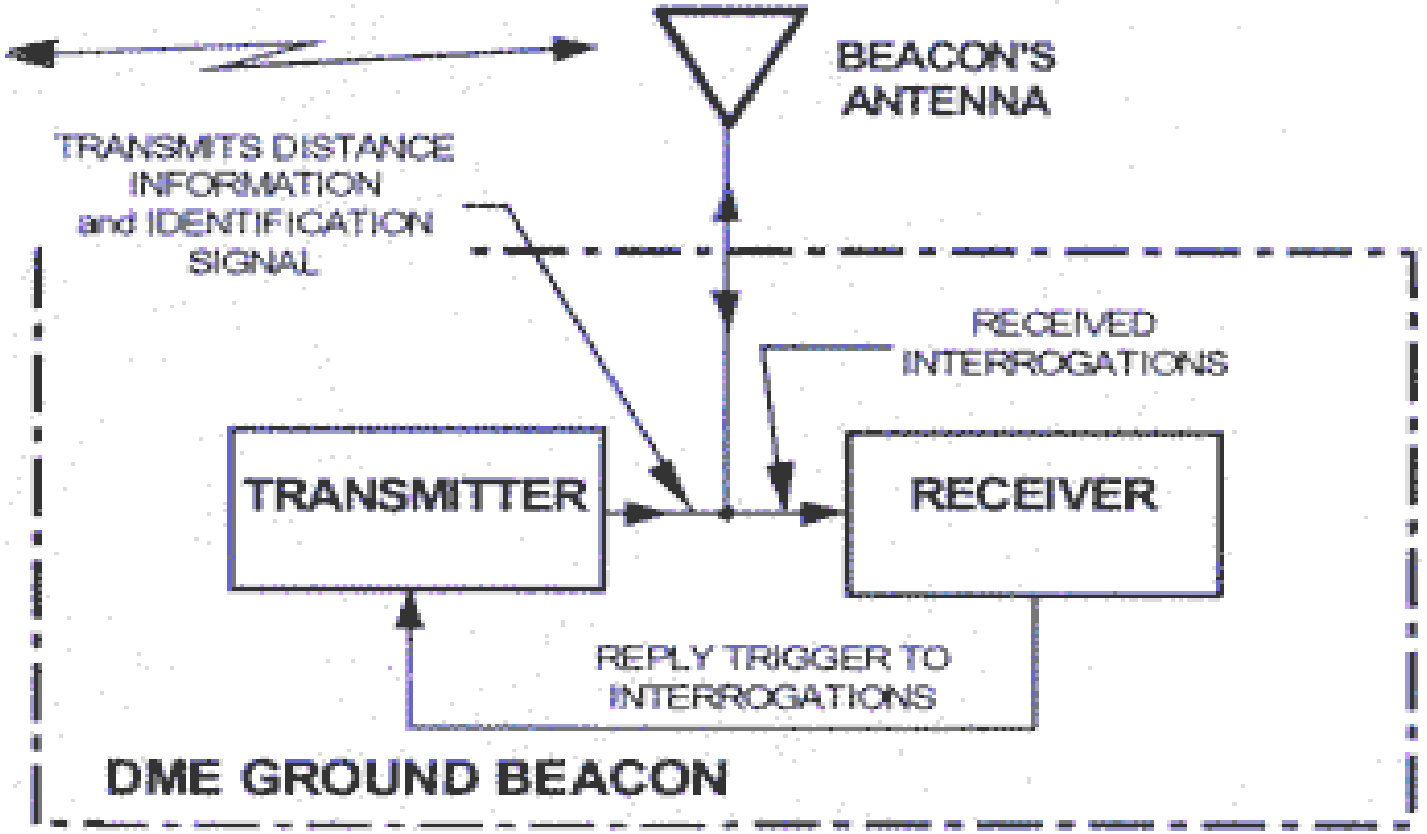
Simplified Block diagram of DME Ground Equipment



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Explain the Principle of DME

Frequency range
962MHz to 1215MHz

$$f_1 - f_2 = 63\text{MHz}$$

$$speed\ of\ interrogation\ or\ reply = 3x10^8 \text{m/s}$$

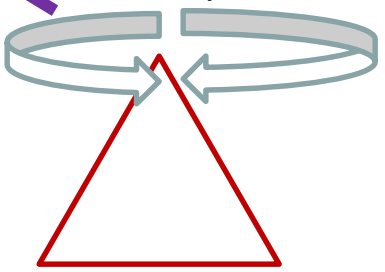
DME Interrogator f_1

t_2

t_1

f_2

$50\mu S$



DME transponder

$$DME\ delay = 50\mu S$$

$$t_T = t_1 + t_2 + 50\mu S$$

$$D = \frac{t_T - 50\mu S}{2}(3x10^8)$$

Feedback

1. The standard system delay as used in the principle of operation of DME Channel X is:

   A. 36uS

   B. 12uS

   C. 50uS

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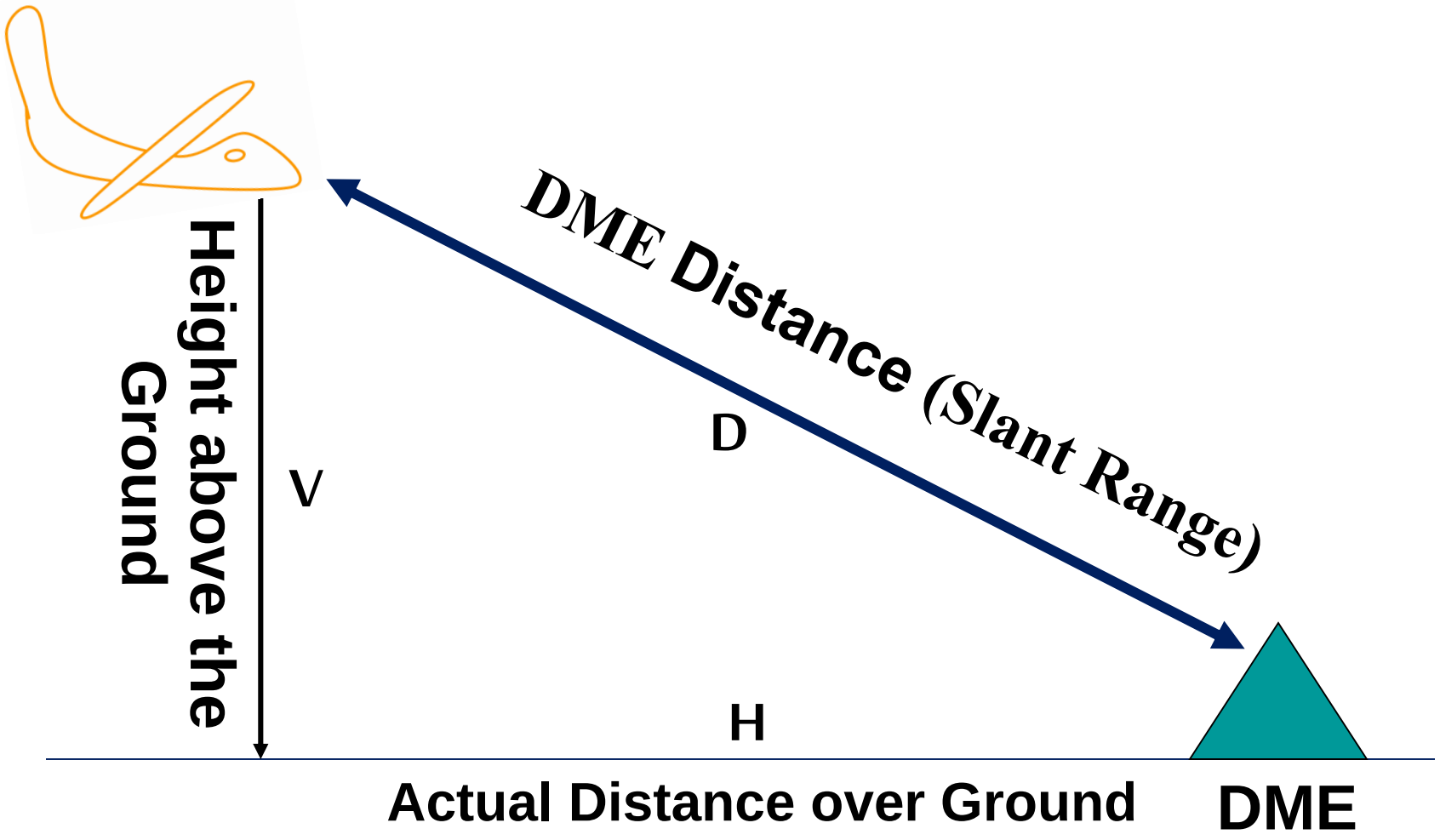
Determine Slant Distance



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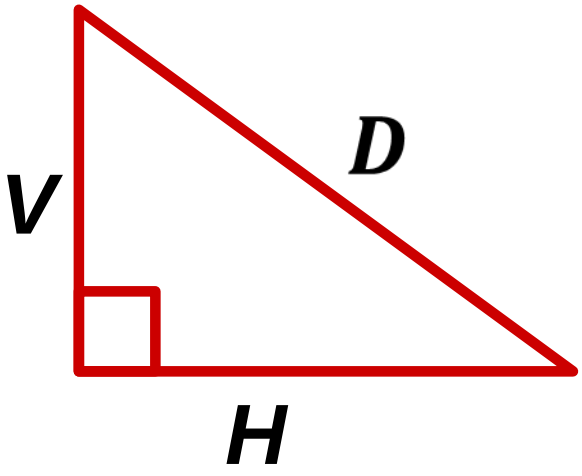
Determine Slant Distance



Pythagoras theorem:

$$D^2 = H^2 + V^2$$

$$for\ D \gg V\ then\ D \cong H$$

$$slant\ error = D - H$$

Slant error is most pronounced at high altitude when close to the DME station

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Feedback

1. The range indicated by DME instrument in the aircraft is:

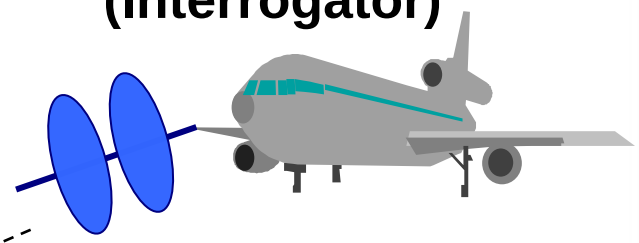
   A. Horizontal

   B. Slant

   C. Vertical

DME Signals

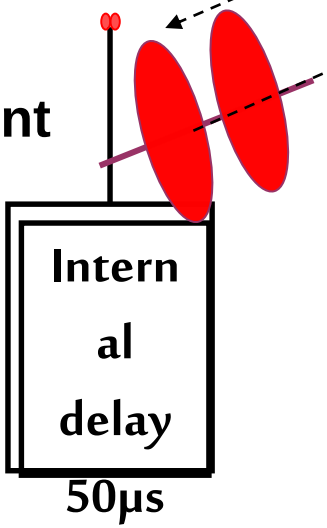
Airborne Equipment (Interrogator)



The Interrogation travels at the speed of light

The Reply travels at the speed of light

Ground Equipment (Transponder)



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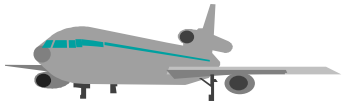
DME Signals

The Airborne Interrogator:

Transmits omnidirectional interrogations



Operates at approximately 27 interrogations per second.

It recognizes the replies to its own interrogations by using unique PRF.

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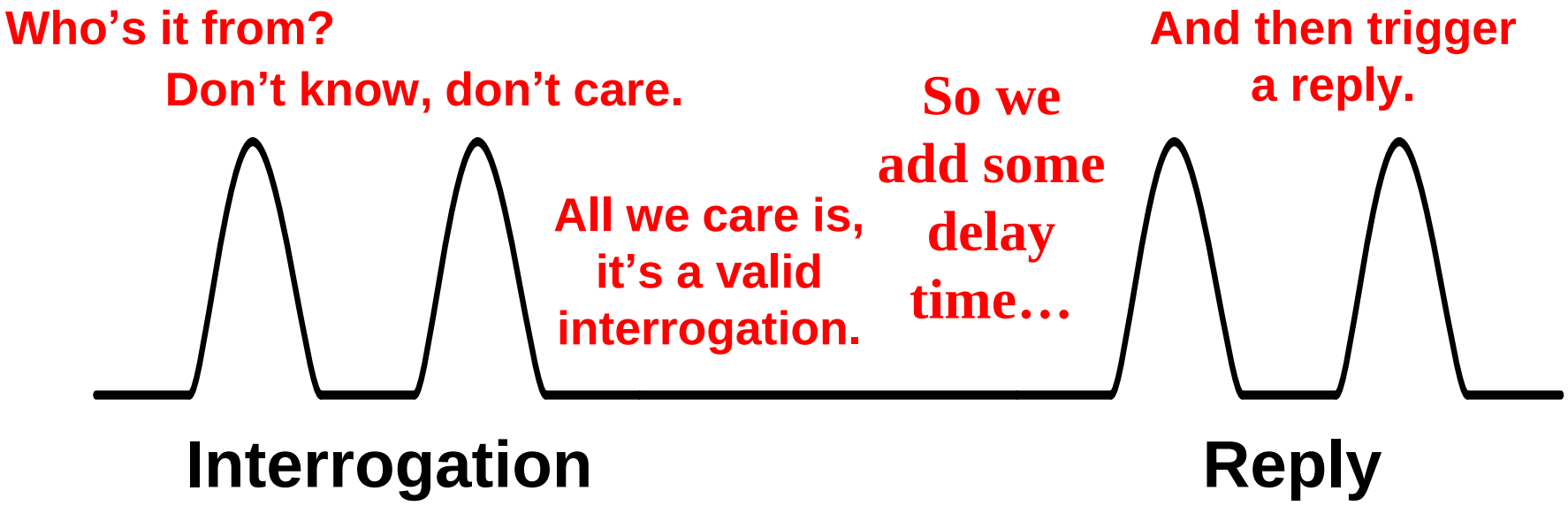
DME Signals

The Transponder:

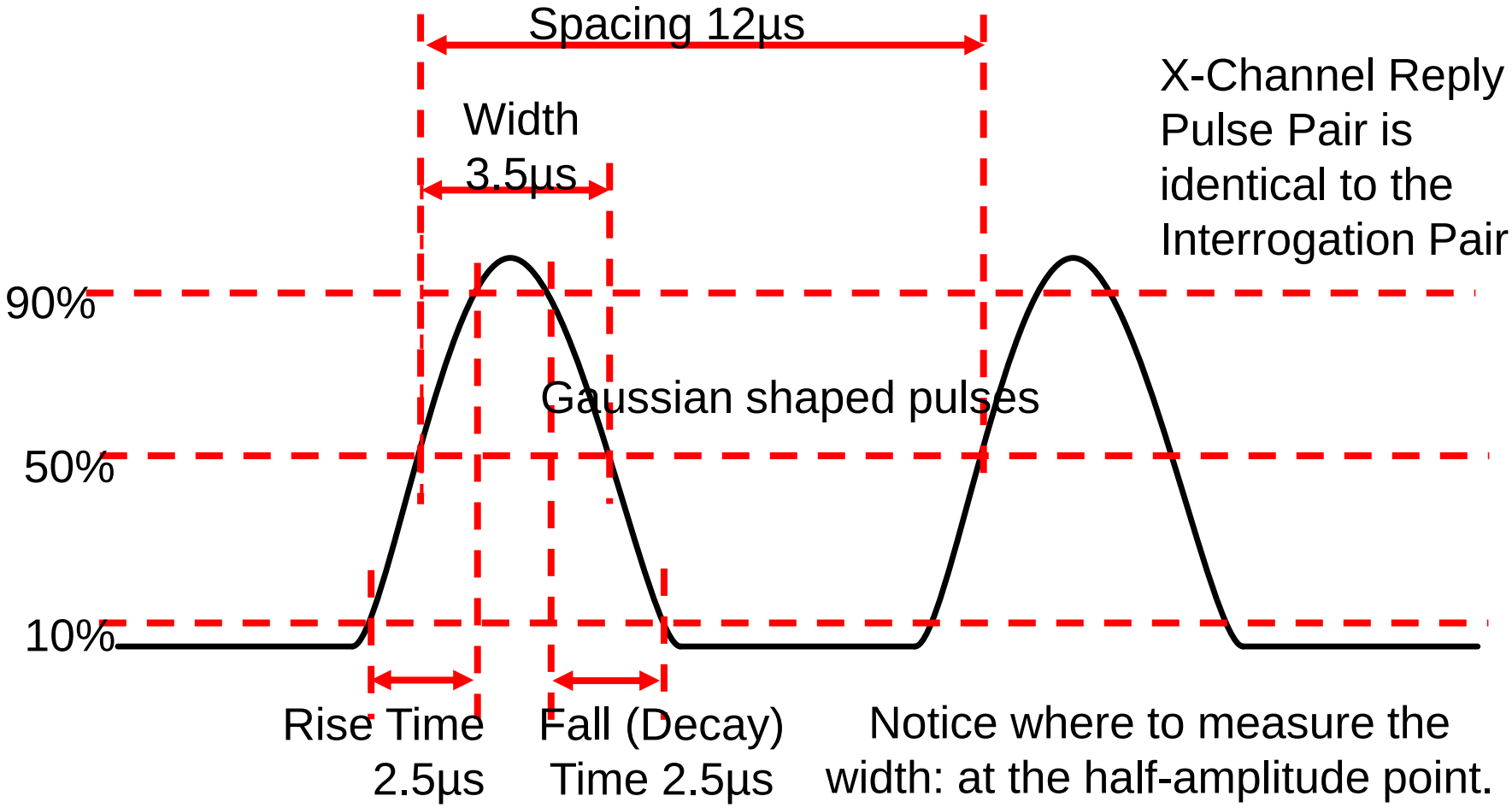
Receives interrogations. Decodes and validates.

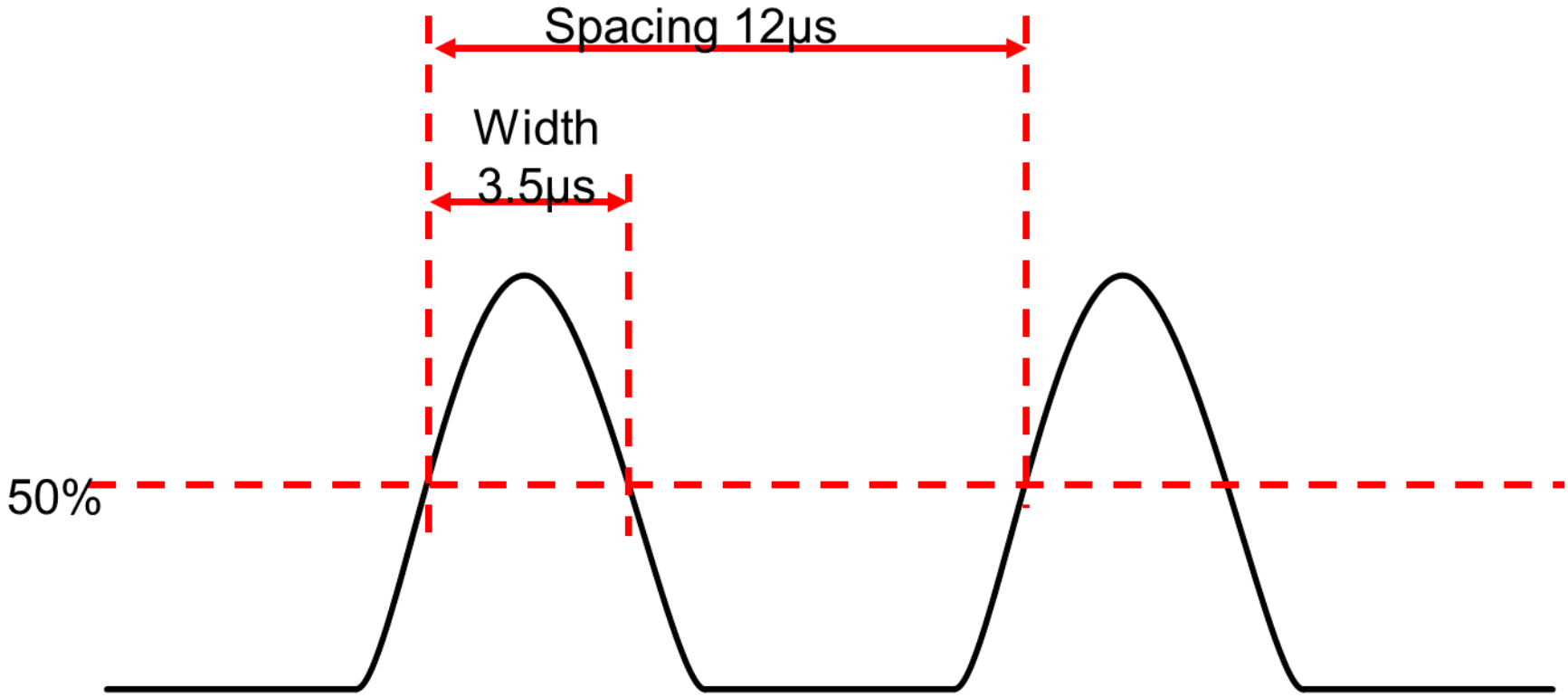


Time from reception of interrogation to emission of reply is 50µs (fixed).

DME Signals

X-Channel Interrogation Pulse Pair




Spacing 12µs
Width
3.5µs
50%

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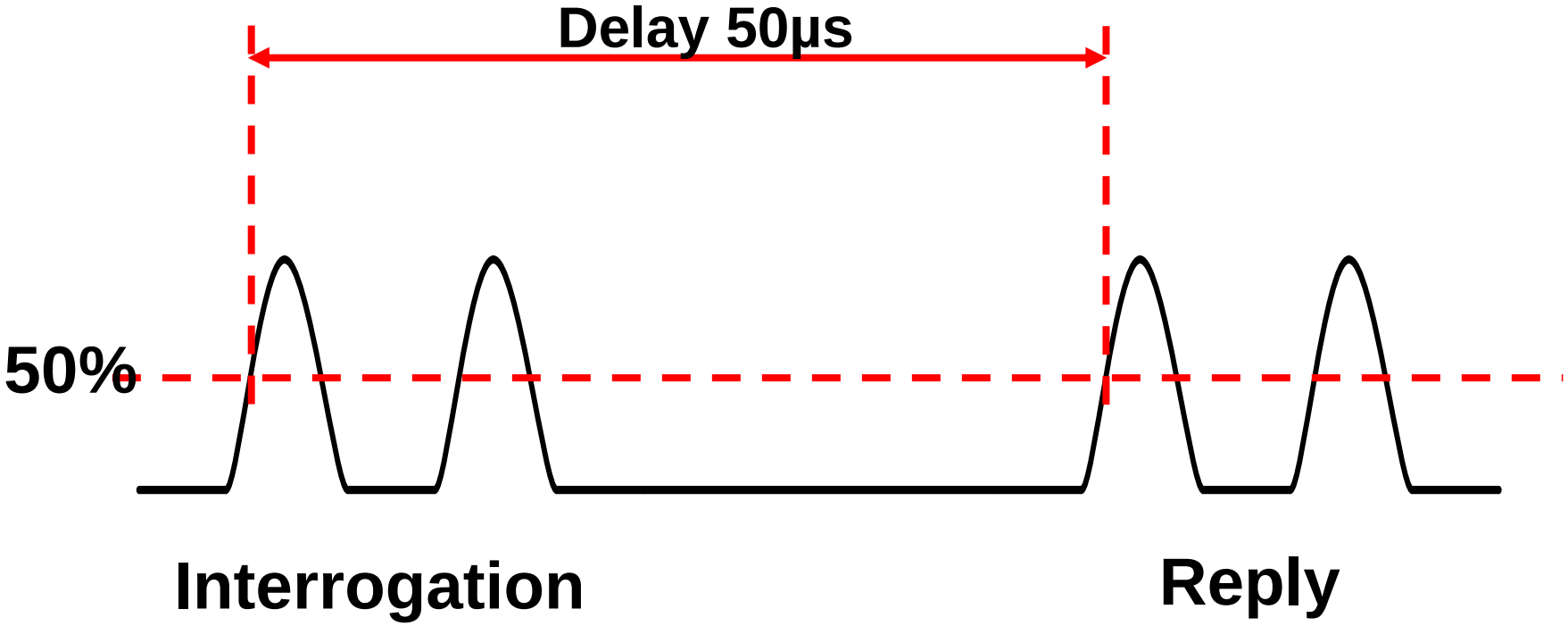
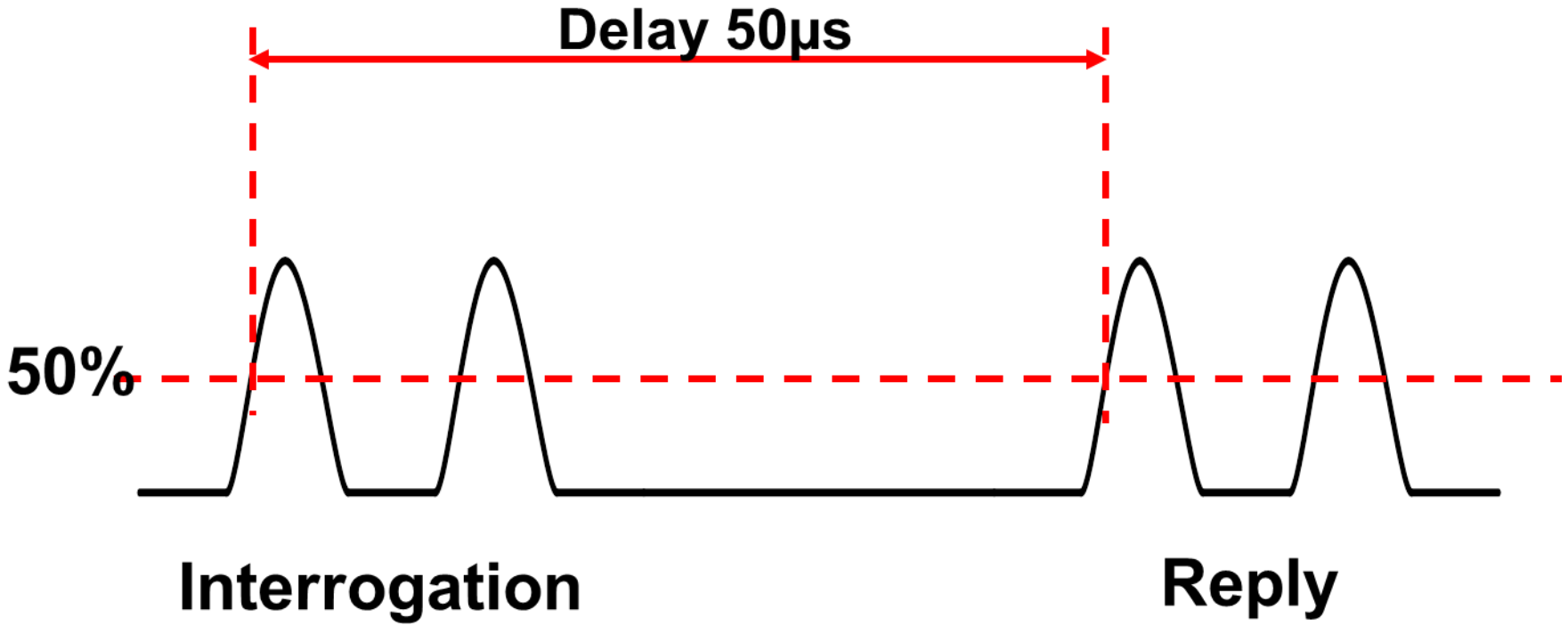
DME Signals

X-Channel Transmitter Delay




Delay 50µs
50%
Interrogation
Reply

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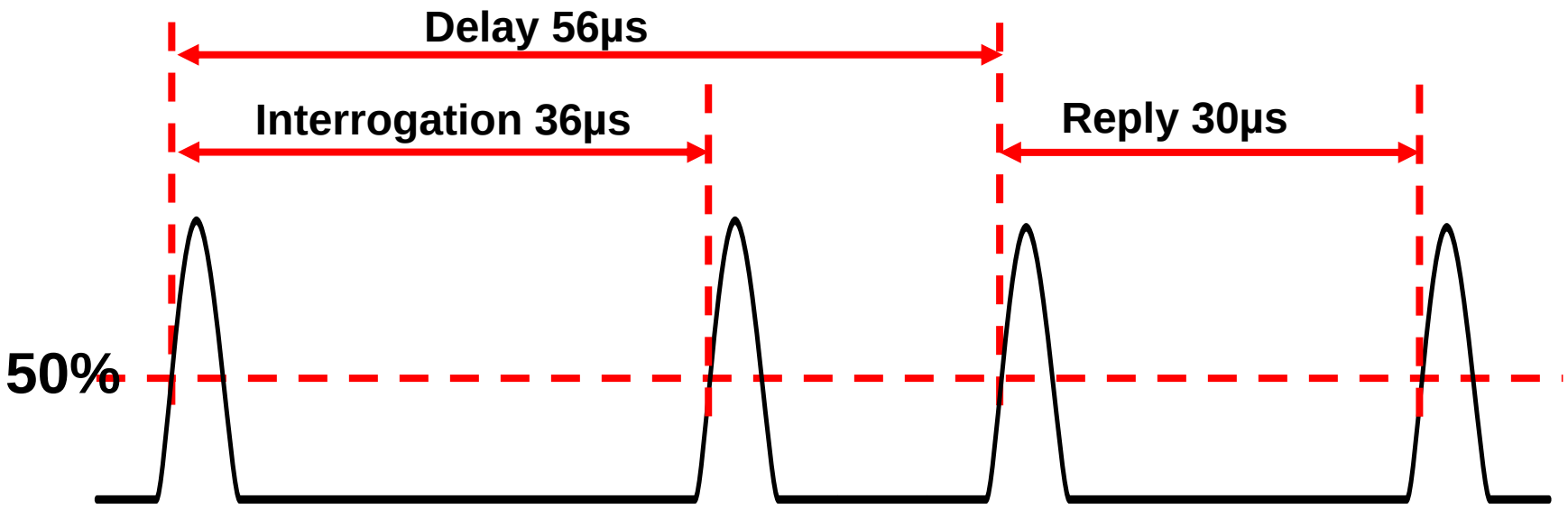
DME Signals

Y-Channel Pulses



Pulse Width, Rise Time and Fall Time are identical to X-Channel pulses

Feedback

1. The pulse spacing time as used in the principle of operation of DME Channel X is:

A. 36uS

B. 12uS

C. 50uS

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Feedback

1. The periods of 3.5uS, 12uS and 50uS in DME channel X respectively represent:

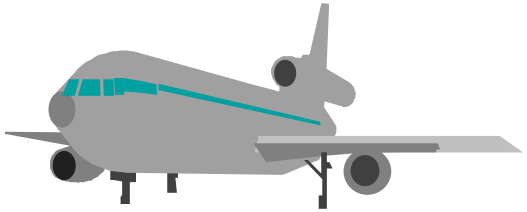
A. Pulse width, pulse spacing, system delay

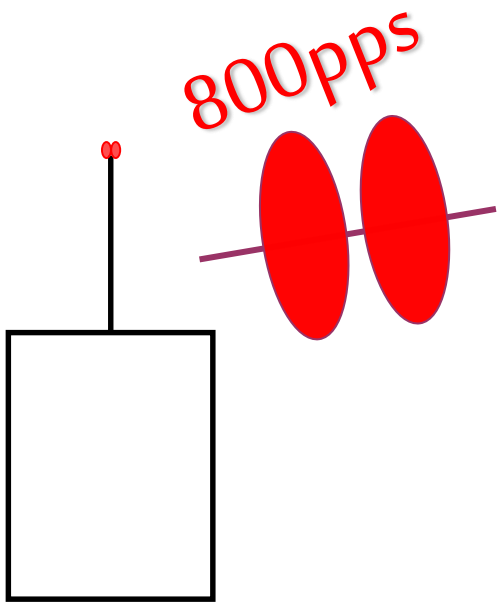
B. System delay, pulse width, pulse spacing

C. Pulse spacing, pulse width, system delay

Underload Control

The DME maintains a minimum duty cycle of 800 pps in order for the aircraft AGC to work efficiently.

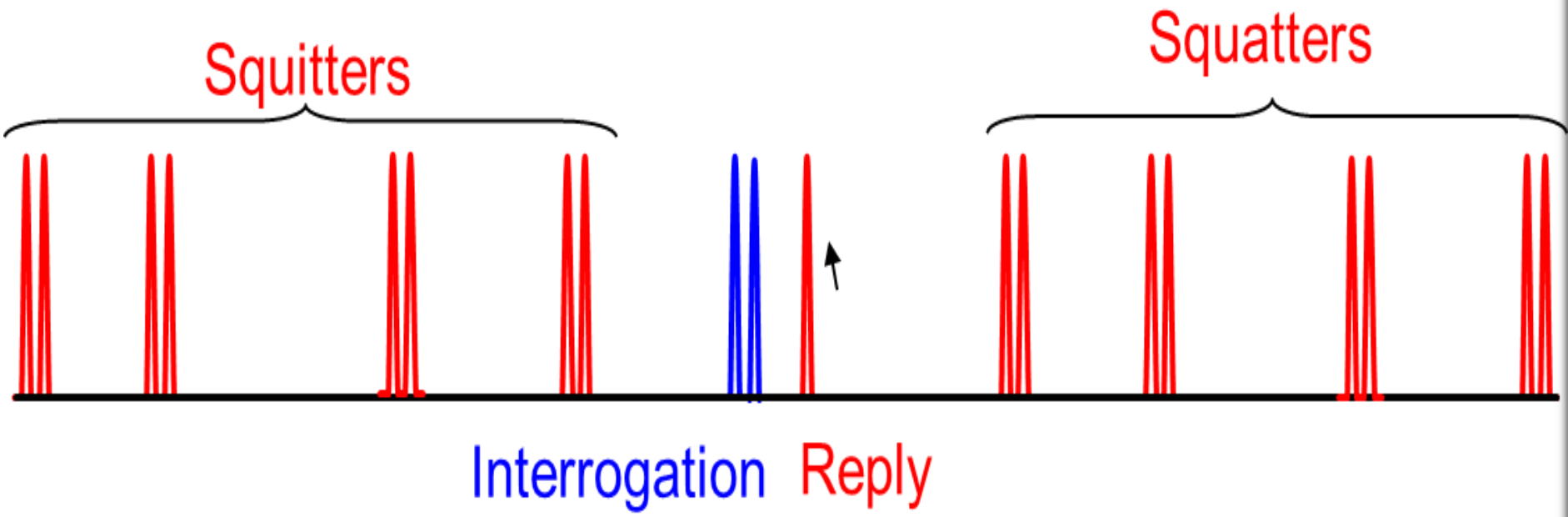




What if interrogations fall below 800pps?

Underload Control

If interrogations fall below 800pps then squitter pulses are randomly generated by transponder to top-up so as to maintain minimum replies of 800pps



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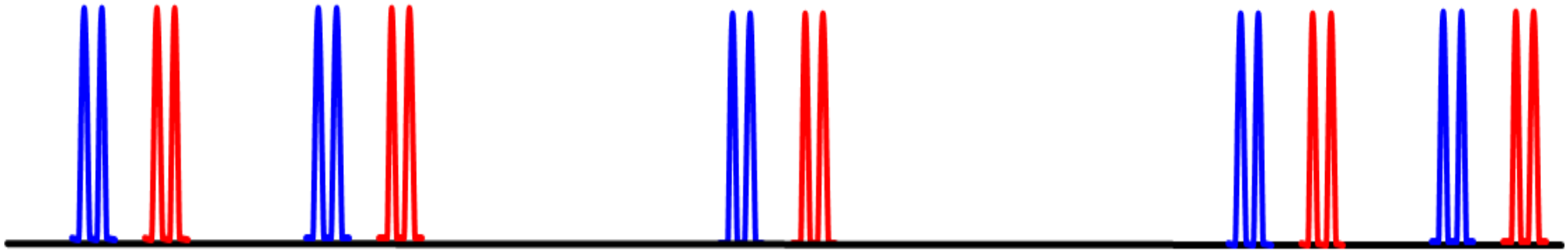
Underload Control

If there are enough replies to produce 800 or more reply pulse pairs per second (pps), then no squitter pulses are produced.



Interrogations are followed by Replies

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Feedback

1. The random pulses generated by the DME to fill in and maintain a constant minimum load are referred to as:

A. Receiver dead time pulses

B. Overload control pulses

C. Squitter pulses

Overload Control

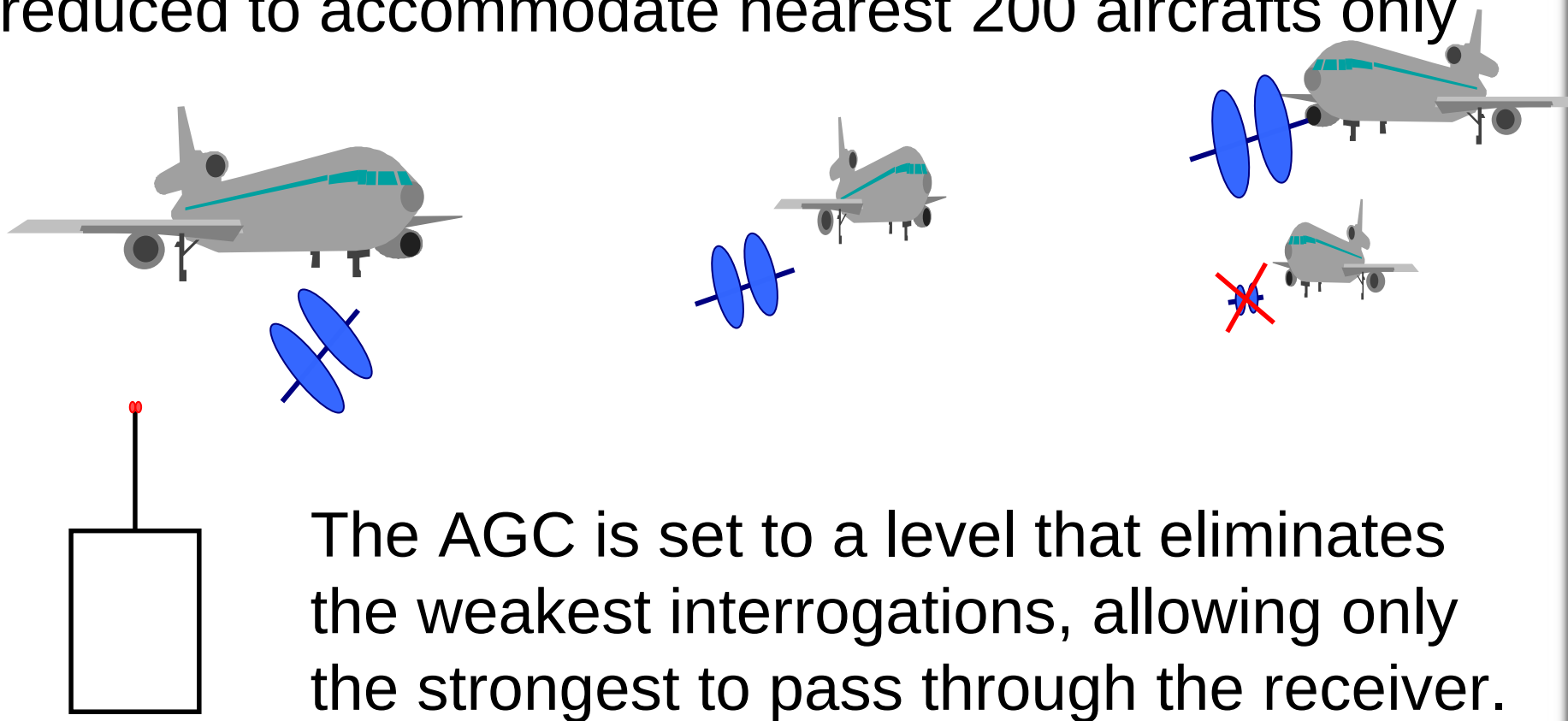
Modern DMEs limit the number of replies to 5400pps to avoid unacceptable level of coincidental interrogations/replies.

5400 pps allows the DME to reply to about 200 airborne interrogators at a time since each aircraft radiates at 27pps

i.e. 27 x 200 = 5400

Overload Control

If interrogations are greater than 5400pps then the transponder sensitivity is reduced by AGC. Range is reduced to accommodate nearest 200 aircrafts only



The AGC is set to a level that eliminates the weakest interrogations, allowing only the strongest to pass through the receiver.

Feedback

1. If a DME transponder is limited to maximum replies of 5400pps, calculate the number of aircrafts whose interrogation will be processed given that each aircraft interrogates at 27pps

A. 100

B. 200

C. 800

Feedback

1. If DME beacon becomes saturated, it adjusts itself using AGC to give priority to:

   A. the nearest aircrafts

   B. the urgent aircrafts

   C. the largest aircrafts

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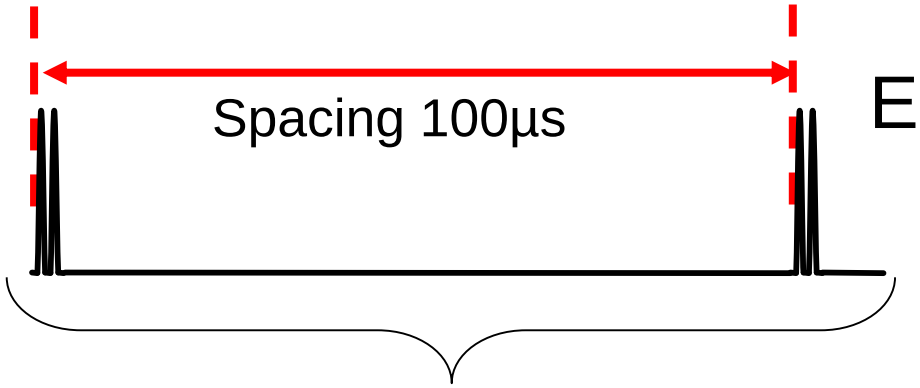
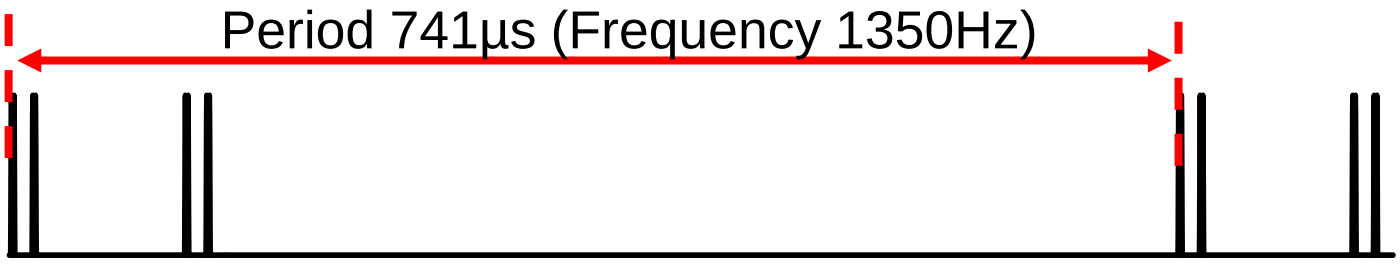
DME Identification

Each DME identifies itself by transmitting a Morse Code at 1350Hz in between interrogations and replies



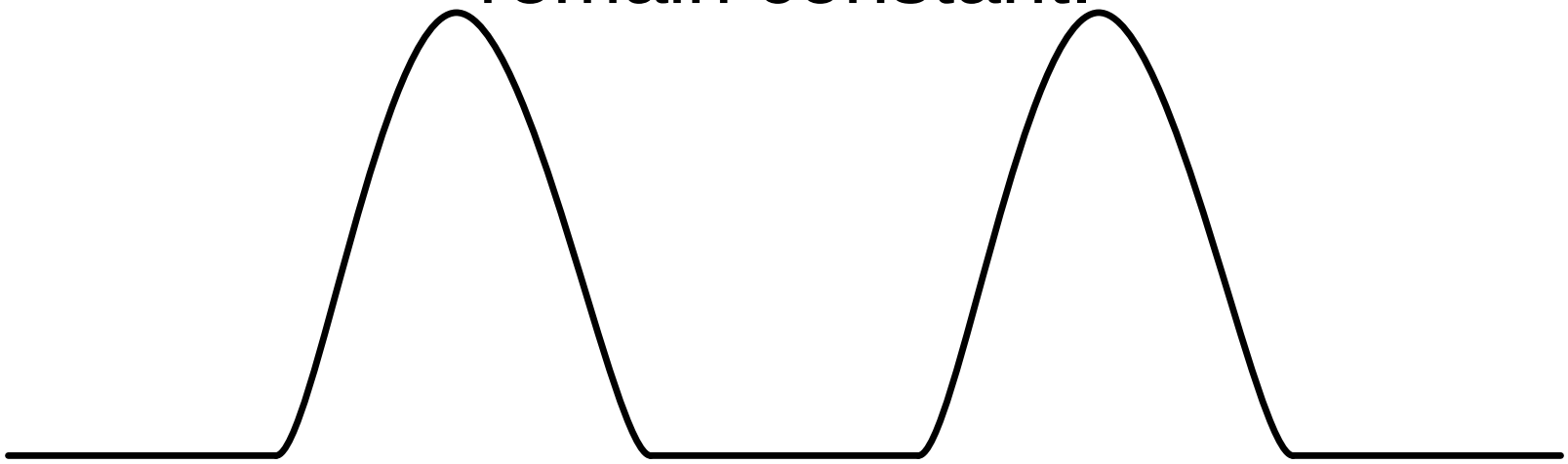
Each group consists of two pulse pairs.



Note

Every time the DME transmitter fires, for any reason (monitor reply, aircraft reply, squitter or identification), it transmits a pulse pair.

Pulse rise time, fall time, width, and spacing remain constant.



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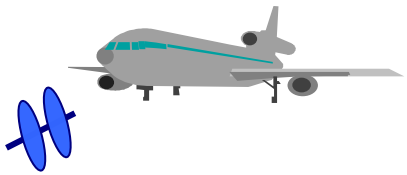
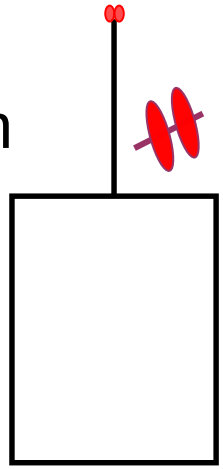
RF Frequencies

Frequency range 962MHz to 1215MHz

The Interrogation is transmitted by the aircraft on one frequency



The Reply is transmitted by the DME Transponder on another frequency



Sometimes the Interrogation frequency is higher, sometimes the Reply frequency is higher. The difference between the two frequencies is always 63MHz

Feedback

1. DME appears in the frequency band of:

   A. VHF

   B. HF

   C. UHF

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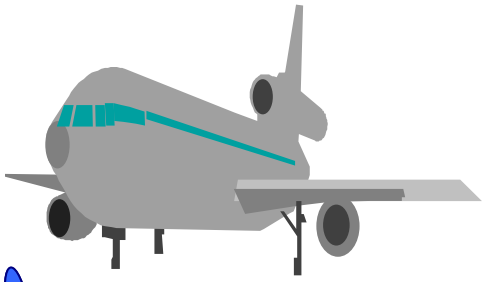
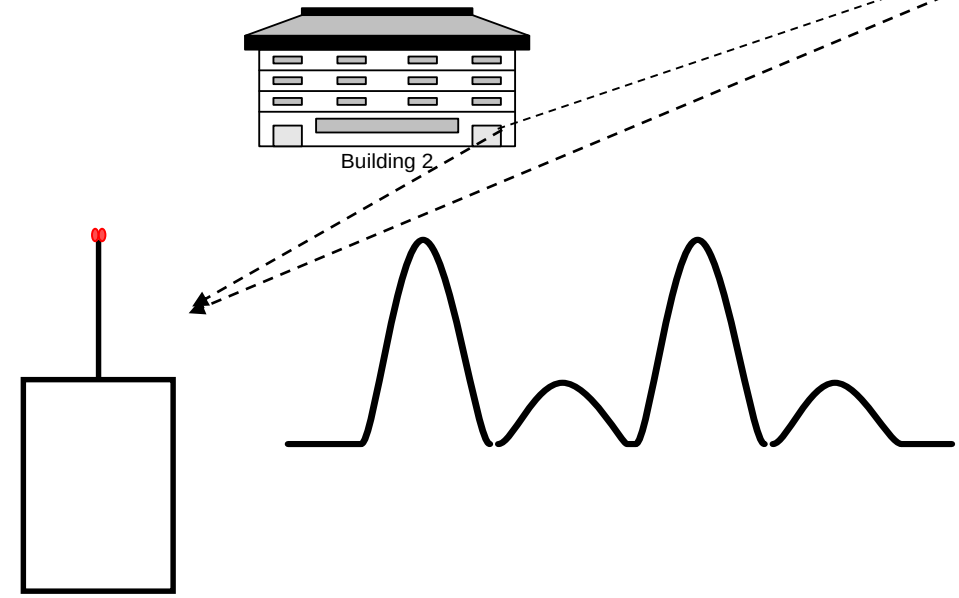
Echo Control

A short distance echo to the first interrogation pulse arrives before the second interrogation pulse arrives.





Transponder recognizes this condition and mutes its receiver for a specified period of time (receiver dead time) for echo to pass, and replies only to the real interrogation.

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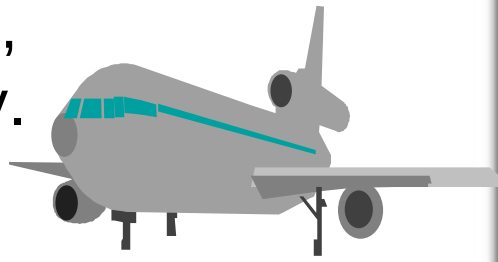
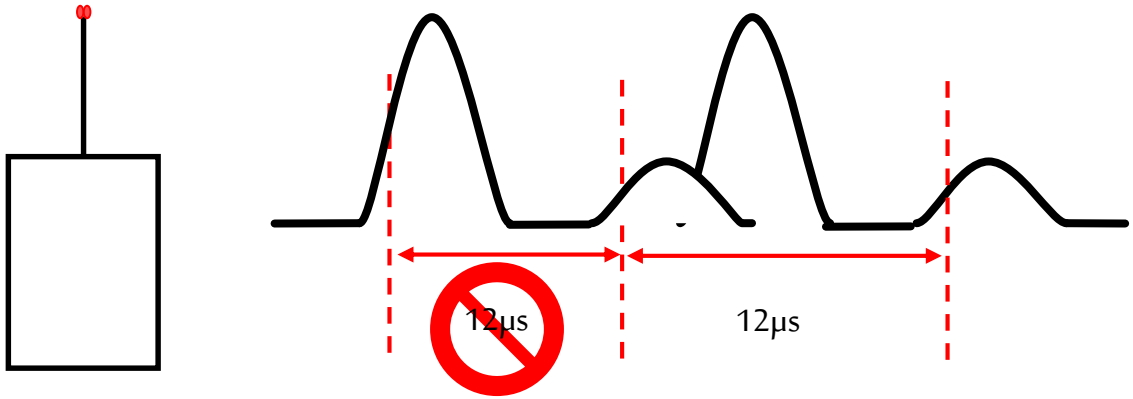
Echo Control

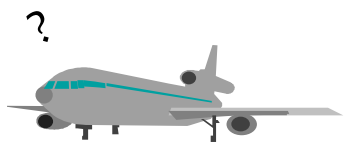
If the first echo overlaps the second pulse, then only the echo would generate a reply. If this condition were allowed, then it is possible that the aircraft would receive incorrect information.

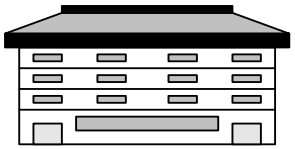


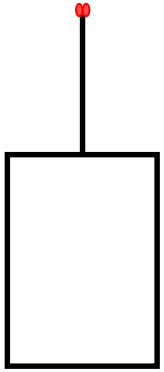


Echo Control

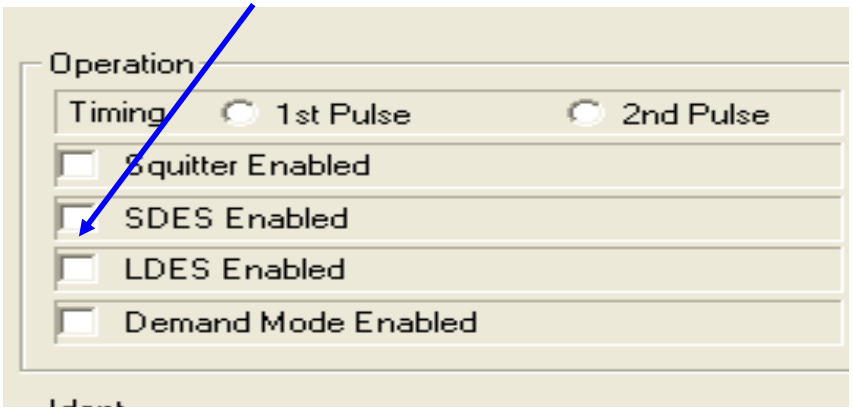
Short distance echoes cause the Airborne Interrogator to receive unstable readings, jumping between two values with a difference of about 1 nm (X channel) or 3 nm (Y channel).





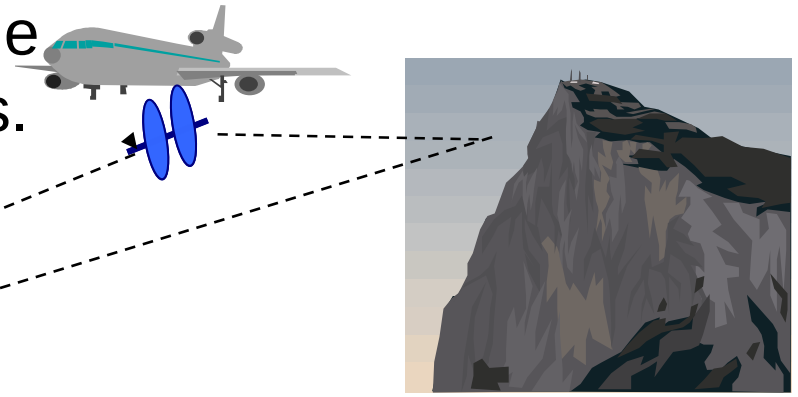


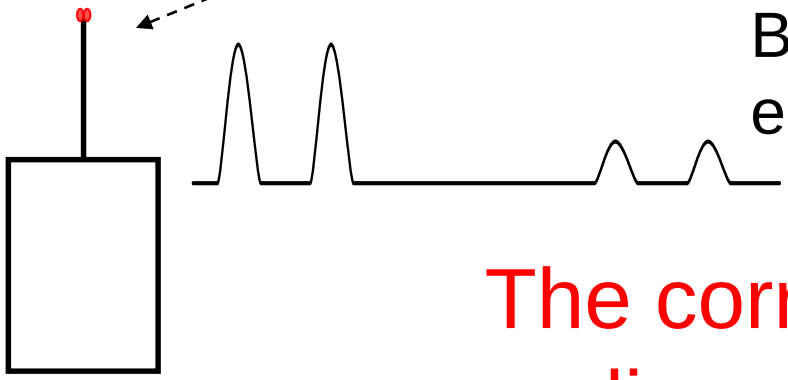
Corrective action: enable Short Distance Echo Suppression (SDES) – also called receiver dead time (RDT)



Echo Control

A long distance echo to the first interrogation pulse arrives after the second interrogation pulse arrives.





Both the interrogation and the echo generate a reply.

The corrective action shall be discussed in next lesson

Feedback

1. Echo errors in DME system are as a result of:

   A. Rough terrain

   B. Doppler effect

   C. Speed of the aircraft

DME Monitored Parameters

Monitoring is necessary to ensure that DME signal is correct and free of error

Parameters

1. Pulse spacing = 12uS
2. System delay = 50uS
3. Efficiency (% no. of replied inter) = 70%

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DME Monitored Parameters

4. PRF (pulse repetition frequency) = 800 – 5400 pps
5. RF power output = 100W or 1000W
6. Identification = 1350 Hz

Feedback

1. Which of the following are the monitored parameters of DME

A. Pulse spacing, 30HZ level, system delay

B. Pulse spacing, efficiency, system delay

C. RF power level, phase difference, identification

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Review

1. State the purpose
2. State the principle
3. Explain the principle
4. Determine slant distance
5. Signals in DME
6. Overload control
7. Echo control
8. Monitored parameters

Next lesson

1. Block diagram of DME interrogator
2. Block diagram of DME transponder
3. Technical description of sequence of signal flow
4. Co-location of DME with ILS or VOR
5. Types of DMEs in the market
6. Future DMEs

Any Questions

Thank you

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Print out

Evaluation

1. With reference to distance measuring equipment

(a) State the purpose of DME in radio navigation **(2 marks)**

(b) Explain the following parameters as used in DME

(i) Pulse spacing **(2 marks)**

(ii) Pulse width **(2 marks)**

(iii) System delay **(2marks)**

(iv) Efficiency **(2 marks)**

(c) State the principle of operation of DME **(4 marks)**

(d) Describe in four steps the sequence of operation of DME system **(8 marks)**

(e) Discuss how the following problems are solved in DME systems

(i) Echoes and reflections **(4 marks)**

(ii) Overload arising from too many aircrafts **(4 marks)**