VOR Hold Autopilot

Prepared
by

A.Kaviyarasu
Assistant Professor
Department of Aerospace Engineering
Madras Institute Of Technology
Chromepet, Chennai

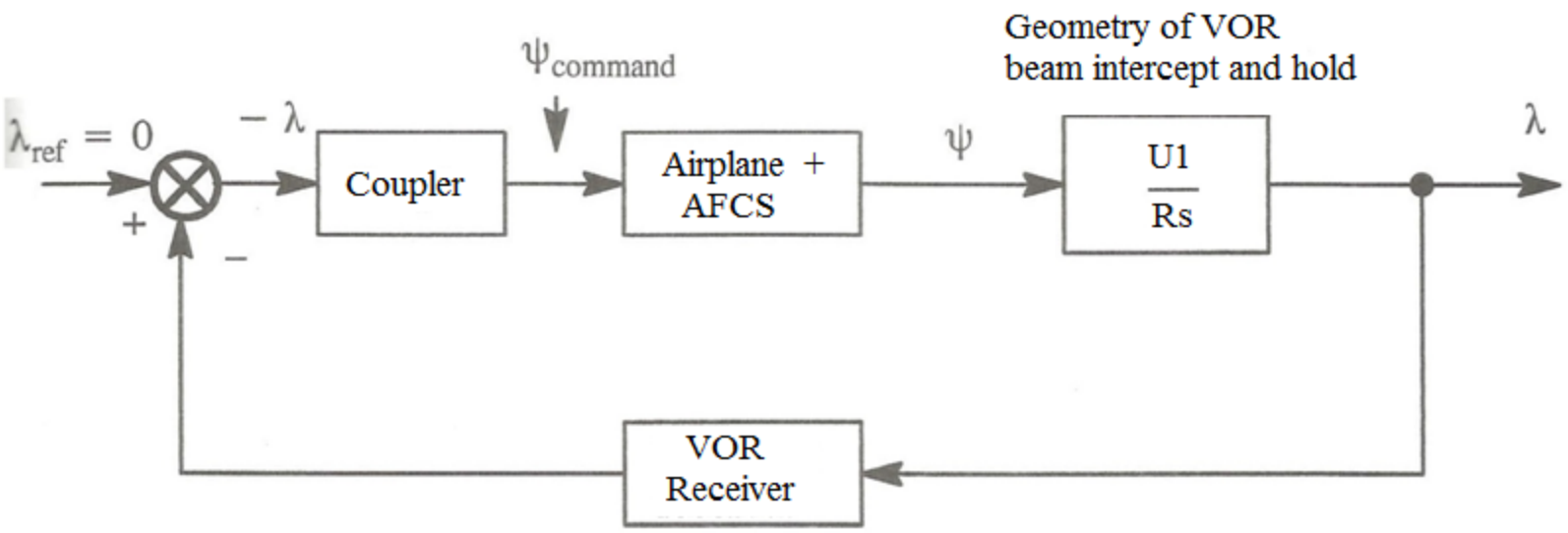
- The synthesis of VOR (or other radio beacon centered navigation) mode is similar to that of the localizer hold mode.

- The main difference is in the width of the beam coming from VOR transmitter.

- The functional diagram of VOR is similar to that of the localizer hold autopilot.

- The only difference is VOR uses VHF/UHF frequency result in it has much higher slant range.


VIDEO
SURVEILLANCE



$$Coupler\ T.F: \frac{\psi(s)}{\psi_{command}(s)} = K_c \frac{(s+0.1)}{s} = 10\frac{(s+0.1)}{s} \qquad K_c = 10\,\text{deg/deg}\,(Typical\ gain\ value)$$

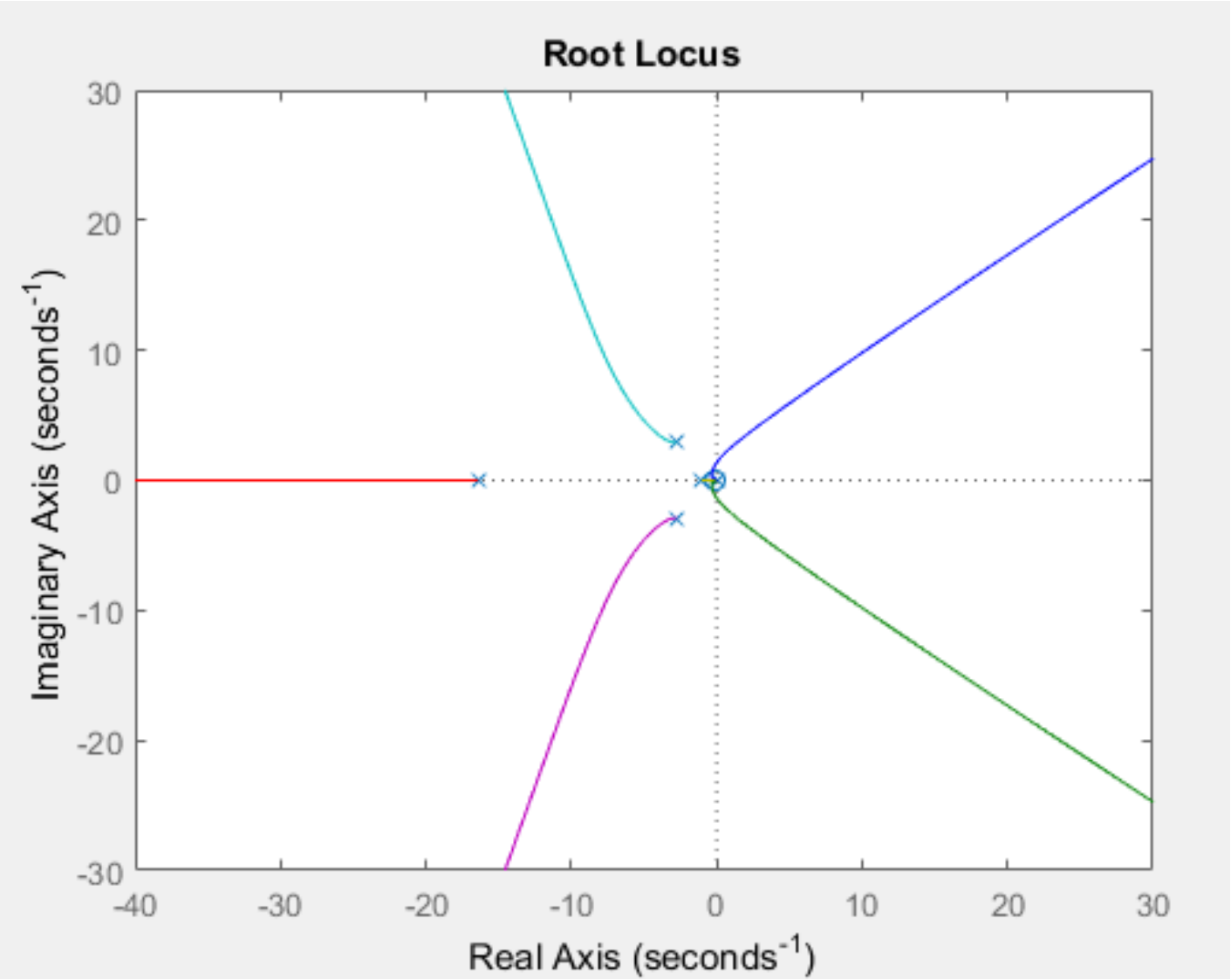
$$Airplane + AFCS\ T.F: \frac{\psi(s)}{\psi_{command}(s)} = \frac{60455}{220.1s^4 + 5062s^3 + 28613s^2 + 82648s + 60455}$$

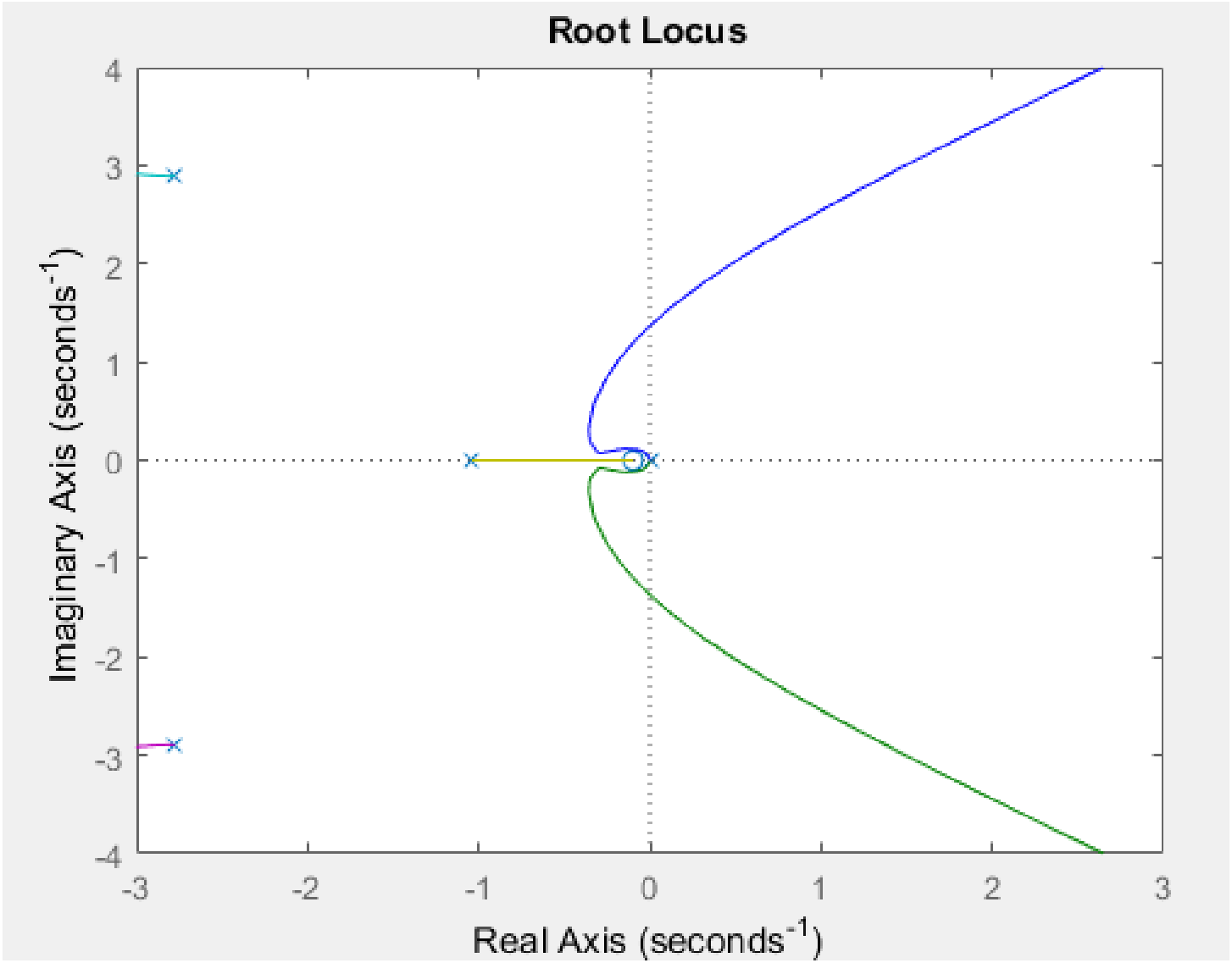
$$Geometry\ T.F = \frac{221}{Rs} \qquad R - Slant\ range\ (1nm = 6076.1\,feet)$$

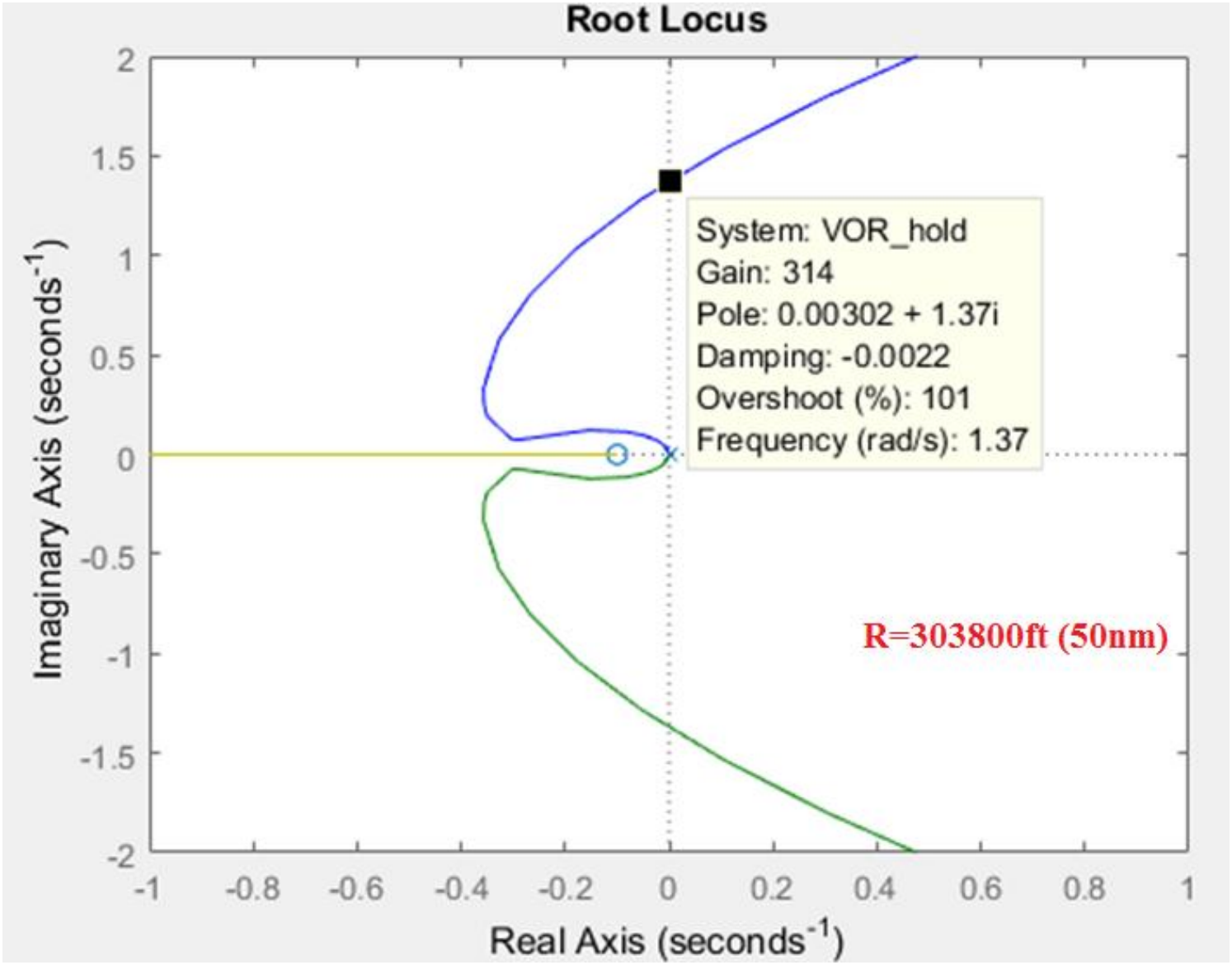
$$VOR\ \text{Re}ceiver\ T.F: 1.0 \qquad U_1 = 221\,ft/\sec\ (during\ approach)$$

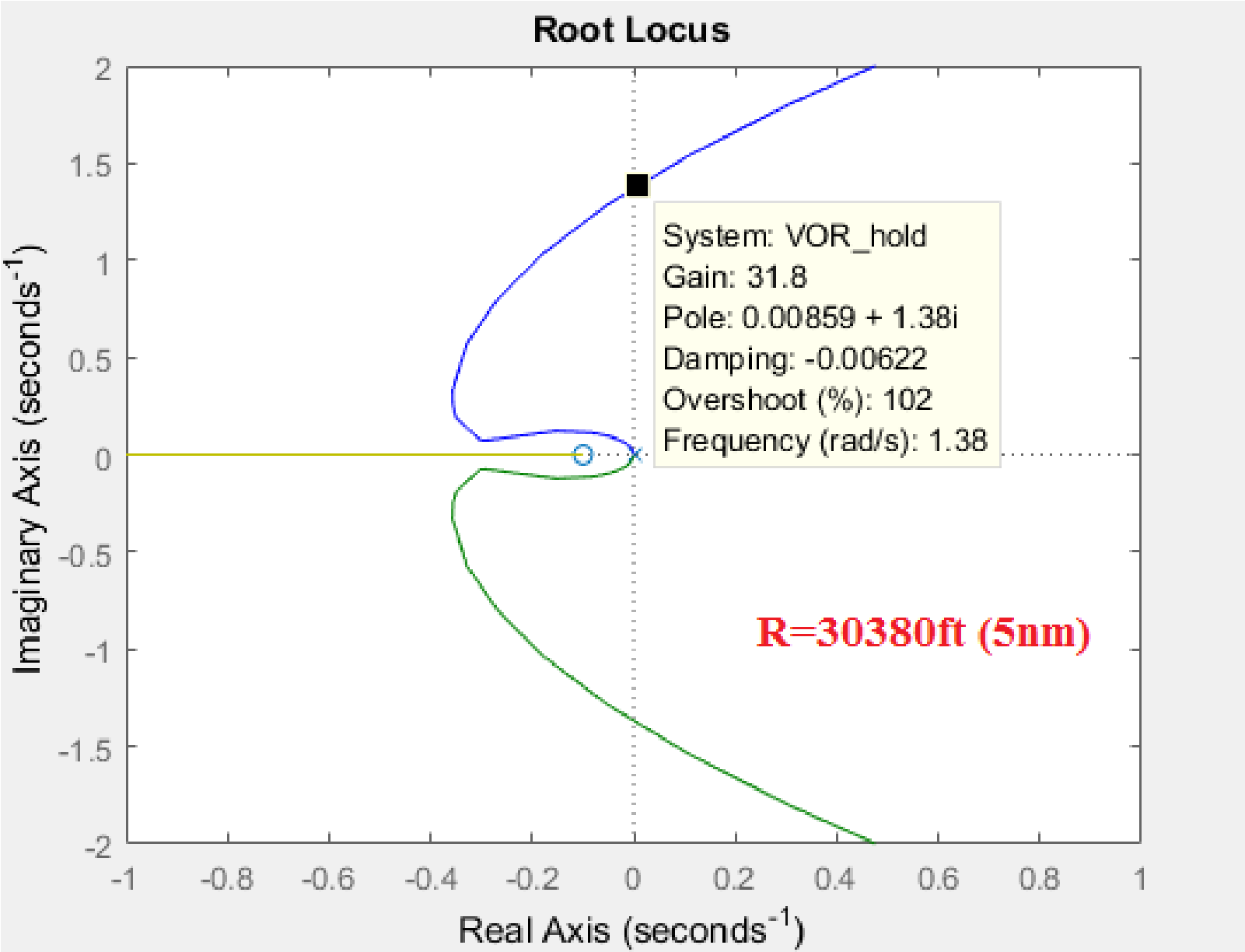
- An example will be shown for airplane A in a 5000ft cruise condition. Because of the excellent inherent roll damping of this airplane no roll damper will be used in the inner loop of bank angle control system. The closed loop heading control system will be used. At gain of K=0.5 deg/deg and K sai 5deg/deg the closed loop transfer function corresponding to the root locus as.

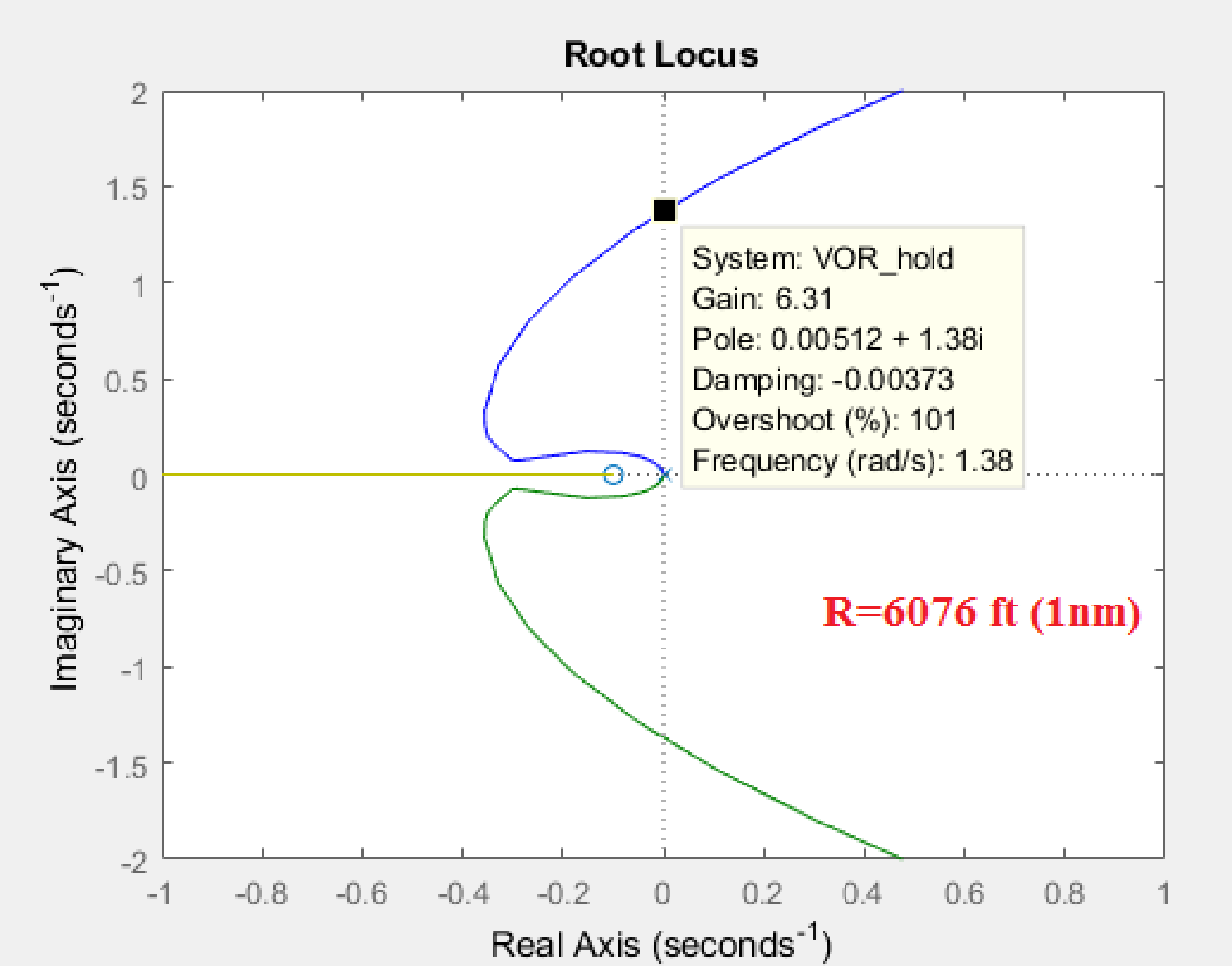
$$\frac{\psi(s)}{\psi_{command}(s)} = \frac{60,455}{220.1s^4 + 5,062s^3 + 28,613s^2 + 82,648s + 60,455}$$

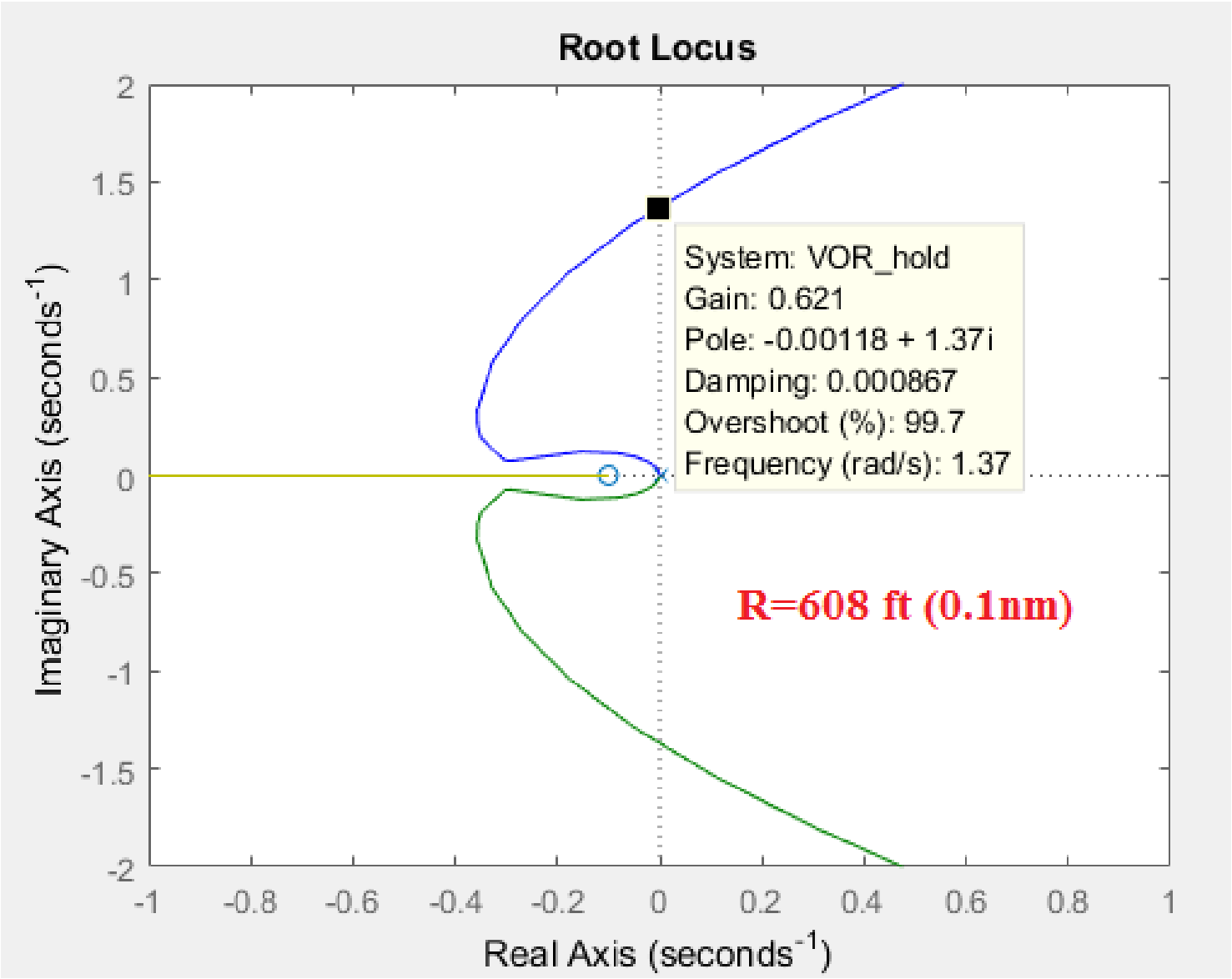

Root Locus
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
30
20
10
0
-10
-20
-30
-40
-30
-20
-10
0
10
20
30


Root Locus
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
4
3
2
1
0
-1
-2
-3
-4
-3
-2
-1
0
1
2
3


Root Locus
System: VOR_hold
Gain: 314
Pole: 0.00302 + 1.37i
Damping: -0.0022
Overshoot (%): 101
Frequency (rad/s): 1.37
R=303800ft (50nm)
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


Root Locus
System: VOR_hold
Gain: 31.8
Pole: 0.00859 + 1.38i
Damping: -0.00622
Overshoot (%): 102
Frequency (rad/s): 1.38
R=30380ft (5nm)
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


Root Locus
System: VOR_hold
Gain: 6.31
Pole: 0.00512 + 1.38i
Damping: -0.00373
Overshoot (%): 101
Frequency (rad/s): 1.38
R=6076 ft (1nm)
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


Root Locus
System: VOR_hold
Gain: 0.621
Pole: -0.00118 + 1.37i
Damping: 0.000867
Overshoot (%): 99.7
Frequency (rad/s): 1.37
R=608 ft (0.1nm)
Imaginary Axis (seconds-1)
Real Axis (seconds-1)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

- The VOR hold loop root locus diagram for this case in shown in figure . Operating points are shown for R=50nm, R=5nm and R=1nm.. This system works well for this airplane even without adjustment to the coupler gain as a function of slant range. Note however, that the constant coupler gain the closed loop damping ratio greatly diminishes as the airplane approaches the VOR transmitted. The behavior is typical of constant gain loops.

Thank You