t za 1/2 obsega zemlje
optika

$c=\frac{c_0}{n}$ $t=\frac{\frac{2\pi \cdot R_z}{2}}{c_0/n}$

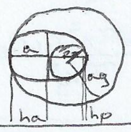
• radijski signal

$t=\frac{2\cdot\sqrt{(h+R_z)^2-R_z^2}}{c_0}$

Polos elipse - razdalja
razmerje sonce - jupiter

$\frac{T_z^2}{a_z^3}=konst.=\frac{T_J^2}{a_J^3}$

$a_J=?$




Perioda tirnice

$r_a=h_a+R_z$ $r_p=h_p+R_z$

$a=\frac{r_a+r_p}{2}$ $T=2\pi\sqrt{\frac{a^3}{\mu}}$

↳ velika polos

$a_g=\sqrt[3]{\mu\left(\frac{T_z}{2\pi}\right)^2}$ $\left(\Delta t=\frac{1}{2}T_p\right)$ do utirjenja

Hitrost satelita

krožnica: $r=a$

elipsa: $r=h_{a/p}+R_z$

$v=\sqrt{\mu\left(\frac{2}{r}-\frac{1}{a}\right)}$

Keplerjeva enačba

krožnica ⇓

$e=0$

$\varphi=E$

$\varphi=E=$

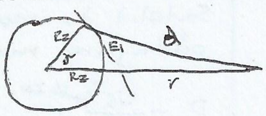
$=\sqrt{\frac{\mu}{a^3}}(t-t_p)$

Vidnost geost. sat.

$\gamma\leq\arccos\left(\frac{R_z}{r}\right)=81.3°$

Kot elevacije

$\frac{\sin(90°+\Theta_E)}{r+R_z}=\frac{\sin\gamma}{d}$




$R=d=\sqrt{R_z^2+(r+R_z)^2-2(r+R_z)R_z\cdot\cos\gamma}$

$\cos\Theta_E=\frac{r\cdot\sin\gamma}{R}=\frac{(R+r_z)\cdot\sin\gamma}{d}$

Goriščna razdalja elipse

$F=a-r_p=a-a(1-e)=ae$

Pomožni kot α in azimut

• zeml. širina: $\varphi_z=\phi$ satelit: Z

$\alpha=\arctan\left(\frac{\tan|\lambda_s-\lambda_z|}{\sin\varphi_z=\phi}\right)=90°$

azimut: SV: $180°-\alpha$

SZ: $180°+\alpha$

JV: $\alpha$

JZ: $360°-\alpha$

kot opazovanja geost. sat.

• zemlj. širina = 66° $v=\varphi_z$

• koordinate (52°, 0°) postaje

elevacija = ? azimut = ?

$\cos\gamma=\cos\varphi_z\cos(\lambda_s-\lambda_z)$ (52°, 66°, 0°)

↳ viden zaradi $\gamma\leq 81.3°$

kot elevacije:

$R=r\sqrt{1+\left(\frac{R_z}{r}\right)^2-2\left(\frac{R_z}{r}\right)\cos\gamma}$

$\cos\Theta_E=\frac{\sin\gamma}{R}$

pomožni kot α

$\alpha=\arctan\left(\frac{\tan|\lambda_s-\lambda_z|}{\sin\varphi_z}\right)$

↓

azimut = ?

Dopplerjev premik

spr. frekvence - opazovalec

$f=\left(1\mp\frac{v}{c}\right)f_0$ + sprej. se oddal. − sprej. se pribl.

− izvor se približuje
+ izvor se oddaljuje $f=\frac{f_0}{1\mp\frac{v}{c}}$

Dopplerjev premik - hitrost vozila

Frekvenca tona $(f_1, f_2)$

$\frac{f_1}{f_2}\Rightarrow v=c\cdot\frac{\frac{f_1}{f_2}-1}{\frac{f_1}{f_2}+1}$

• netopir - hitrost

$f=f_0\cdot\frac{1+\frac{v}{c}}{1-\frac{v}{c}}\Rightarrow v=c\cdot\frac{\frac{f}{f_0}-1}{\frac{f}{f_0}+1}$

Dopplerjev pomik Δf pri sprejemu satelita

$(e=0,\ a=R_z+h=r)$

$v=\sqrt{\mu\left(\frac{2}{r}-\frac{1}{a}\right)}$

$v_z=R_z\omega_z=R_z\frac{2\pi}{T_z}$

$\Delta v=v\cos\alpha-v_z=v\cdot\frac{R_z}{R_z+h}-v_z$

$\Delta f=f_0\cdot\frac{\Delta v}{c_0}$

Najmanjši potrebni Δv, da ne pade nazaj

• velika polos elipse: $a=R_z$

• perigej: $r_p=R_z=6378$

$v_p=\sqrt{\mu\left(\frac{2}{r_p}-\frac{1}{a}\right)}=\sqrt{\frac{\mu}{R_z}}$

• da ubeži, damo $a=\infty$

Zmanjšan potrebni začetni sunek Δv, če izkoristimo vrtenje zemlje?

$T_z=24ur\cdot 60min-4min=1436min$

$v_z=\frac{2\pi R_z}{T_z}$

• da ubežimo s pomočjo $v_z$

$\Delta v=v_p-v_z$

Sprememba energije ΔW do krožnice (od prenosne krožnice)

$a_p=\frac{r_a+r_p}{2}$ $W_p=-\frac{Mm}{2a_p}$ $\left(\frac{1}{2}mv^2-\frac{\mu}{r}\cdot m\Rightarrow v\right)$ $\Delta W=W_g-W_p=+\omega$

$a_g=h_a+R_z$ $W_g=-\frac{Mm}{2a_g}$

Reakcijska sila - pospešek

$a=v_i\cdot\frac{\Delta m}{m}$ $[m/s^2]$

Ostanek goriva za premik satelita

$v_i=g\cdot I_{sp}$ $\Delta v=-v_i\ln\frac{m_g+m_t}{m_g'+m_t}$

↳ hitrost izpuha

$m_g'=(m_g+m_t)\cdot e^{-\frac{\Delta v}{v_i}}-m_t$ $\Delta v=v_g-v_s$

Hitrost Ariane5, brez goriva

$v=v_i\ln\left(\frac{m_0}{m_0-m_g}\right)$

Naklon tirnice brez precesije perigeja

$5\cos^2 i-1=0$ $\cos i=\pm\sqrt{\frac{1}{5}}\Rightarrow i=\pm 63.435°$

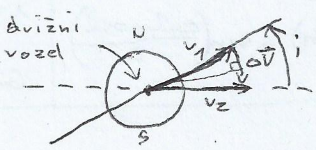
Popravek naklona geostacion. tirnice

⇓

$i=5°$

sprememba hitrosti:

$\Delta v=2v\cdot\sin\left(\frac{\Delta i}{2}\right)\approx v\cdot\Delta i$ ← v rad




Satelit Molnija - argument perigeja ω, da bo najdlje nad severno poloblo, apogej ha, ekscentričnost e?

$T=2\pi\sqrt{\frac{a^3}{\mu}}\Rightarrow a=\sqrt[3]{\mu\left(\frac{T}{2\pi}\right)^2}$

$h_a=2a-2R_z-h_p$ $\omega=270°$

$h_p+R_z=r_p=a(1-e)\rightarrow e=1-\frac{h_p+R_z}{a}$

višina geost. tirnice in hitrost

$T=2\pi\sqrt{\frac{a^3}{\mu}}\rightarrow a=\sqrt[3]{\mu\left(\frac{T}{2\pi}\right)^2}$

$h=a-R_z$

$v=\sqrt{\mu\left(\frac{2}{r}-\frac{1}{a}\right)}=\sqrt{\frac{\mu}{a}}$ $T=1436min$

$\mu=3.986\cdot 10^{14}\frac{m^3}{s^2}$ $R_z=6378km$

Temperatura satelita v obliki krogle (črno telo)

valj → $A_s=2rh$

$f_s=f_0=1$ $A_s=\pi r^2$ → površina, ki sprejema sev.

$A_0=4\pi r^2=4A_s$ → površina, ki oddaja sev.

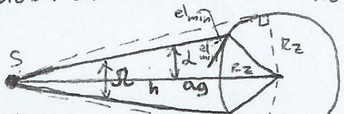
$P_s=A_s\cdot S_s\cdot f_s=A_s\cdot S_s$ → sprejeta moč

$P_0=\sigma\cdot A_0\cdot f_0\cdot T^4=\sigma\cdot 4A_s\cdot T^4$ → oddana moč

Ravnovesna temp: $S_s=1.4kW/m^2$

$T=\sqrt[4]{\frac{S_s}{4\cdot\sigma}}$ $\sigma=5.67\cdot 10^{-8}\frac{W}{m^2K^4}$

Smernost antene za celotno poloblo




$\sin\alpha=\frac{R_z}{a_g}$

$\Omega=2\pi(1-\cos\alpha)=2\pi\left(1-\sqrt{1-\sin^2\alpha}\right)=$

$=2\pi\left(1-\sqrt{1-(R_z/a_g)^2}\right)$

$D=\frac{4\pi}{\Omega}=\frac{2}{1-\sqrt{1-\left(\frac{R_z}{a_g}\right)^2}}$

⇓

$D_{dB}=10\log D=[dBi]$

• za vidnost vsaj $el_{min}=15°$

$\frac{\sin\alpha}{R_z}=\frac{\sin(el_{min}+\pi/2)}{R_z+h}$ $\alpha=\arcsin\left(\frac{R_z}{R_z+h}\cdot\cos el\right)$

$\Omega=2\pi(1-\cos\alpha)$ $D=\frac{4\pi}{\Omega}=\frac{2}{1-\cos\alpha}$

Matar