31310 Linear Control Design 2

Compulsory Assignment 2015 : Loudspeaker control

by

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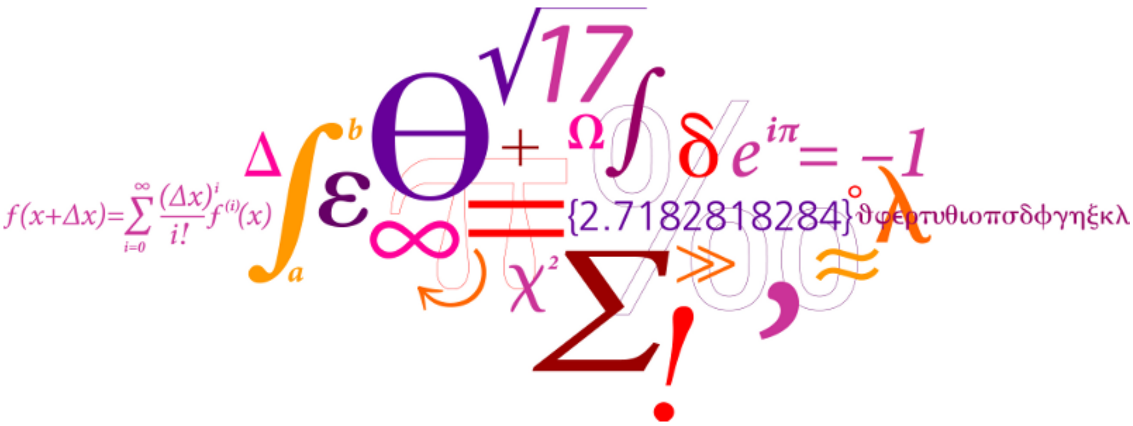

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0.1 Problem 1

First of all, the irradiance F of the light from the sun falling at the top of the atmosphere of Mars can be calculated as following : Conservation of energy :

$$4\pi R_{\odot}^2 F_{\odot} = 4\pi R^2 F \tag{1}$$

with

$R_{\odot} = 6,956.10^8\ m$: solar radius
$F_{\odot} = 6,45.10^7\ W.m^{-2}$: energy flow of the surface of the sun
$R \in [2.06644,\ 2.49228].10^{11}\ m$: distance Mars-Sun (Aphelion and Perihelion)

$$F = F_{\odot}\left(\frac{R_{\odot}}{R}\right)^2 \in [502, 730]\ W/m^2 \tag{2}$$

In this report, we will consider that the rover is working on a specific date and we will chose the one when R corresponds to the semi-major axis. In this case $R = 2,27936.10^{11}\ km$ and

$$F = 589\ W/m^2 \tag{3}$$

Moreover, we can assume that a part of the irradiance is absorbed by the atmosphere. Knowing that the atmosphere of Earth absorbs and scatters to space around 30% of the incident irradiance of the Sun[3], and knowing that the atmosphere of Mars is thinner than the one of the Earth, we will postulate that 10% of the incident irradiance is absorbed. Thus, using 3 the actual irradiance F_a of the light from the sun falling on the surface of Mars is

$$F_a = \frac{90}{100}F = \frac{90 * 589}{100} = 530\ W/m^2 \tag{4}$$

However, this irradiance is the one of surface exposed perpendicular to the sun's beams. As Mars is a sphere, the projection need to be considered. Knowing that the weather is better into the northern hemisphere of Mars[2] and the fact that a latitude between 30 an 70 degrees is favored for a landing[1], we will assume that the rover has a latitude of 50°. This latitude corresponds to an angle of 40° between the surface of Mars and the sun's beams. Moreover, suppose that the rover stop working when this angle is inferior to 10°. Thus, the irradiance F_{50} at a latitude of 50° is

$$F_{50} = F_a sin(angleBeams) \in [92, 341]\ W/m^2 \tag{5}$$

with $angleBeams = [10, 90 - latitude] = [10, 40]°$.

Then, considering the trajectory of the Sun into the sky of Mars and knowing that the rock target is more or less vertical to the surface of Mars, the angle θ between the target's normal and the sun's beam is considered to be included in $[10, 50]°$. In addition, in the optimal case (when all the optimal conditions are provided to have the maximal radiance), the BRDF of the surface of the target is assumed to be 90% Lambertian and 10% Glossy while in the worst case the BRDF will be only Lambertian. In this way, the radiance of the target R_T is

$$R_T = \begin{cases} \frac{F_{50}\alpha}{\pi} \cos\theta & \text{optimal case} \\ F_{50}\alpha(\frac{9}{10\pi}\cos\theta + \frac{1}{10}) & \text{worst case} \end{cases} \tag{6}$$

with

$\alpha \in [0.05, 0.45]$, the albedo of the target**??**

$\theta \in [10, 50]°$, the angle between the target's normal and the sun's beam

Thus,

$$R_T \in [92, 340]\ W/m^2 \tag{7}$$

References

[1] John Leif Jørgensen, 2015.

[2] Wikipedia. Mars — Wikipedia, the free encyclopedia, 2004. [Online; accessed November 18, 2015].

[3] Giichi Yamamoto. Direct absorption of solar radiation by atmospheric water vapor, carbon dioxide and molecular oxygen. *Journal of the Atmospheric Sciences*, 19(2):182–188, 1962.