

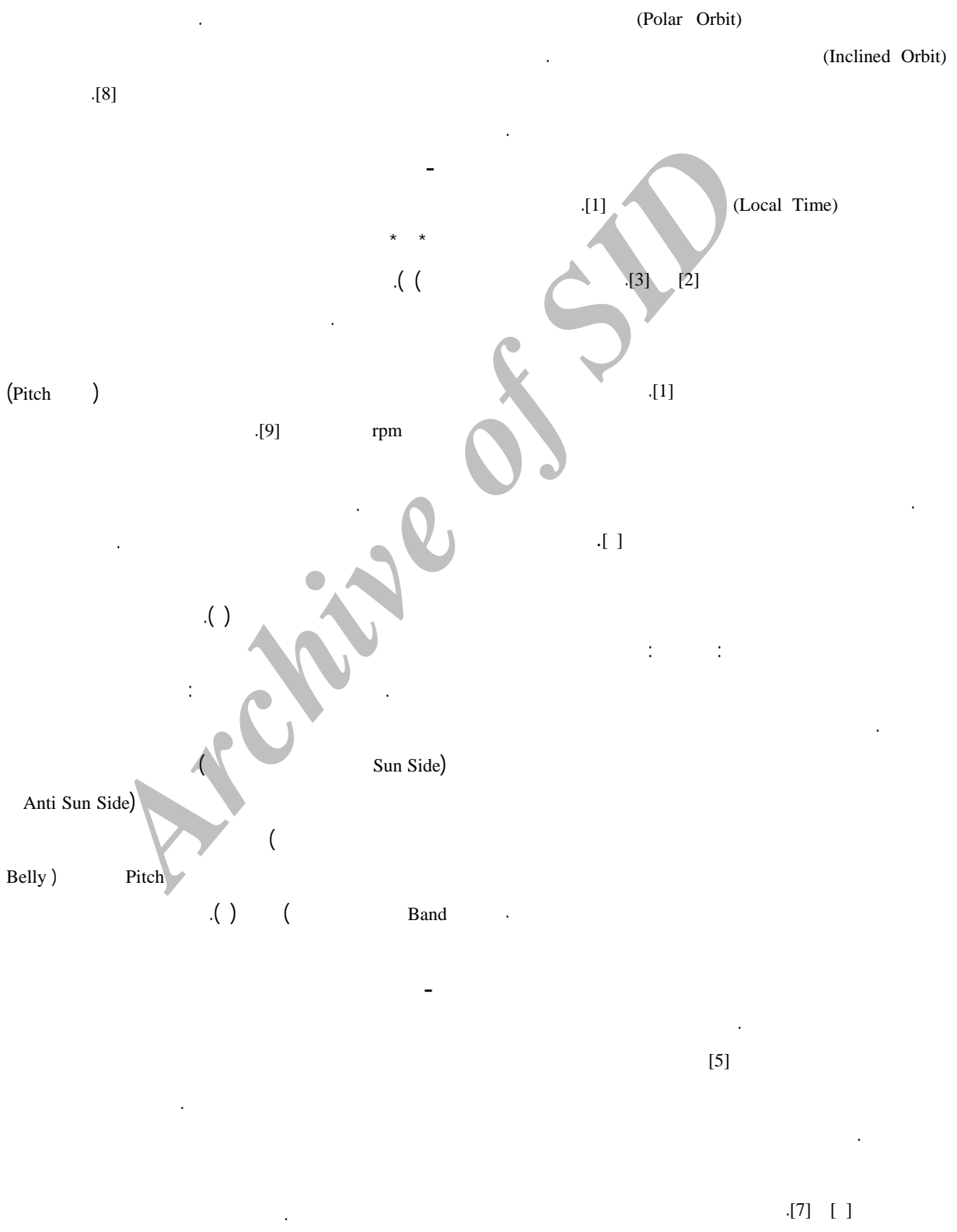
Effect of Orbital Parameters on Satellite Temperature Distribution Located in Sun-synchronous Orbit

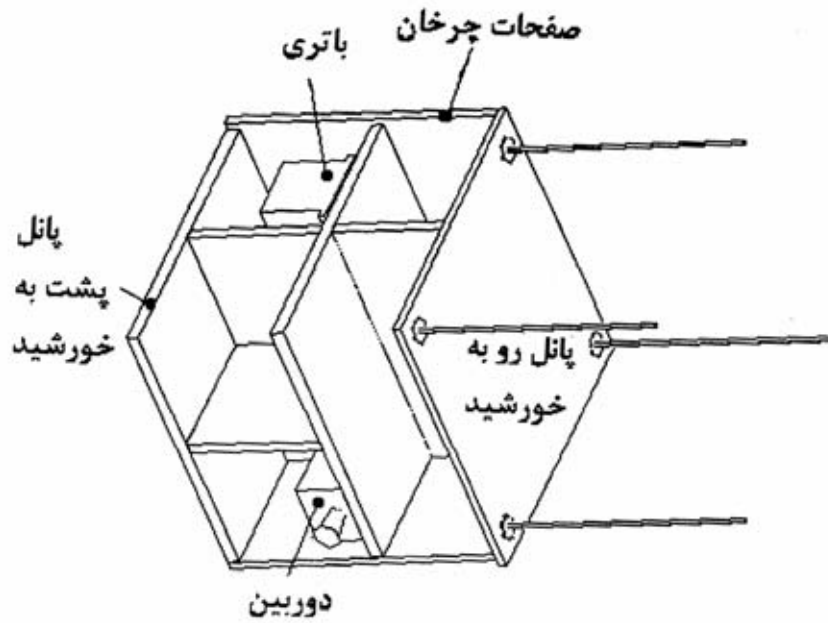
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Abstract

The goal of this paper is to investigate the effect of orbital parameters on thermal behavior of a small satellite located in sun-synchronous orbit. In sun-synchronous orbit, altitude and local time are the most important parameters that influence the satellite thermal design. These parameters influence satellite boundary conditions. The governing energy equations are a system of coupled nonlinear algebraic equations. For thermal analysis a finite difference method, lumped parameter method, is used. Thermal network for heat interacting nodes are drawn and a finite difference based code is utilized to solve the set of non-linear algebraic equations. Results show that internal component temperature increase when altitude increase. Also, at 10:30 local time internal components show higher temperature than 12:00 local time.

Key words: Sun Synchronous Orbit, Beta Angle, Altitude, Local Time





$$F_{12H} = 2 \int_0^{\cos^{-1} \frac{1}{1+v}} \frac{B \times \sin \varphi \times \cos \varphi - B^{\frac{1}{2}} \times \sin^3 \varphi}{A^2} d\varphi \quad (1)$$

() ()

[2]

$$F_{12V} = \frac{2}{\pi} \int_0^{\cos^{-1} \frac{1}{1+v}} \frac{B^{\frac{1}{2}} \sin^2 \varphi \cos \varphi - \sin^4 \varphi}{A^2} d\varphi \quad (2)$$

$$P = 2\pi \left(\frac{a^3}{\mu} \right)^{\frac{1}{2}} \quad (3)$$

B A () ()

$$RI = \arccos \left[- (0.09910) \left(\frac{a}{6371} \right)^{3.5} \right] \quad (4)$$

$$A = \left[1 + (1+v)^2 - 2(1+v) \cos \varphi \right]$$

$$398601.19 \text{ Km}^3 / \text{s}^2 \quad (5)$$

(μ)

$$B = \left[1 + (1+v)^2 - 2(1+v) \cos \varphi - \sin^2 \varphi \right]$$

(1) Ascending node

()

()

:Ascending Node -

[11]

() []) β (

$$f_E = \begin{cases} \frac{1}{180^\circ} \text{Cos}^{-1} \left[\frac{(h^2 + 2Rh)^{0.5}}{(R+h)\text{Cos}\beta} \right] & \text{if } |\beta| < \beta^* \\ 0 & \text{if } |\beta| \geq \beta^* \end{cases} \quad () \quad \beta \quad \text{[]}$$

$$f_E () \quad \beta = \text{Sin}^{-1}(\text{Cos } \delta_s \cdot \text{Sin} RI \cdot \text{Sin}(\Omega - \Omega_s) + \text{Sin } \delta_s \cdot \text{Cos} RI) \quad ()$$

() β^*

$$\beta^* = \text{Sin}^{-1} \left[\frac{R}{R+h} \right] ; 0 \leq \beta^* \leq 90^\circ \quad ()$$

$\Omega_s = \dot{\Omega}_t$ Ω_s

$\dot{\Omega}$

0.9856Deg/day

$\Omega = \dot{\Omega}t + \Omega_0$

$\Omega - \Omega_s = \Omega_0$ ()

[] Ω_0

() ()

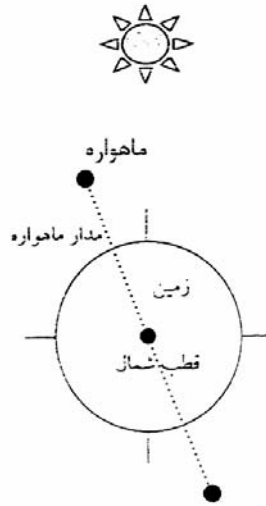
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Ω_0

$$Q_{\text{Sun-Belly Band}} = A \cdot \alpha_s \cdot S_a \cdot \text{Cos} \beta / \pi \quad () \quad \delta_s$$

$$Q_{\text{Sun-Sun side}} = A \cdot \alpha_s \cdot S_a \cdot \text{Sin} \beta \quad () \quad ()$$

$$\delta_s = 23.4 \times \sin \left(\frac{2\pi}{365.25} \cdot t \right) \quad ()$$



$$Q_{albedo-Sun, Anti Sun Side} = A \cdot \alpha_s \cdot S_a \cdot f_a \cdot \cos \theta \cdot F_{12V} \cdot \sin \beta \quad ()$$

$$m_i c_{P_i} \frac{dT_i}{dt} + \sum_{j=1}^n C_{ij} (T_i - T_j) + \sum_{j=1}^{n+1} R_{ij} (T_i^4 - T_j^4) - Q_i = 0 \quad ()$$

$$Q_{albedo-Belly Band} = A \cdot \alpha_s \cdot S_a \cdot f_a \cdot \cos \theta \cdot F_{12H} \cdot \cos \beta / \pi \quad ()$$

$$\Delta t \frac{dT_i}{dt} \quad () ()$$

$$\frac{dT_i}{dt} = \frac{T'_i - T_i}{\Delta t} \quad ()$$

$$Q_{earth-sun, Anti sun side} = A \cdot \varepsilon \cdot G \cdot F_{12V} \quad ()$$

$$(t + \Delta t) \quad ()$$

$$Q_{earth-Belly Band} = A \cdot \varepsilon \cdot G \cdot F_{12H} / \pi \quad ()$$

$$R_{ij} \quad C_{ij} \quad () \quad ()$$

$$G \quad S_a \quad () \quad ()$$

$$() ()$$

$$f_a \quad /$$

[] /

$$\begin{aligned}
 & () \quad m_i c_p \frac{(T_i - T_i)}{\Delta t} + f \left(\sum_{j=1}^n C_{ij} (T_i - T_j) \right) \\
 & () () \quad + \sum_{j=1}^n R_{ij} (T_i^4 - T_j^4) + R_{i-space} (T_i^4 - T_{space}^4) \\
 & \quad + (1-f) \left(\sum_{j=1}^n C_{ij} (T_i - T_j) \right) + \sum_{j=1}^n R_{ij} (T_i^4 - T_j^4) \\
 & \quad + \sigma R_{i=space} (T_i^4 - T_{space}^4) = Q_i \quad ()
 \end{aligned}$$

$$C_{ij} = \frac{K_{ij} A_{ij}}{L_{ij}} \quad ()$$

$$R_{ij} = \sigma \varepsilon_i \varepsilon_j A_i F_{ij} = \sigma \varepsilon_i \varepsilon_j A_i F_{ji} \quad ()$$

Q_i

(())

(Node) n

n*n

()

()

Anti Sun Side

()

()

()

()

()

() ()

: : -

		:		:				
F _{12H}	F _{12V}	%	β (Degree)	%	β (Degree)	(Sec)	(Degree)	(km)
/	/	/	/	/	/		/	
/	/	/	/	/	/		/	
/	/	/	/	/	/		/	
/	/	/	/	/	/		/	
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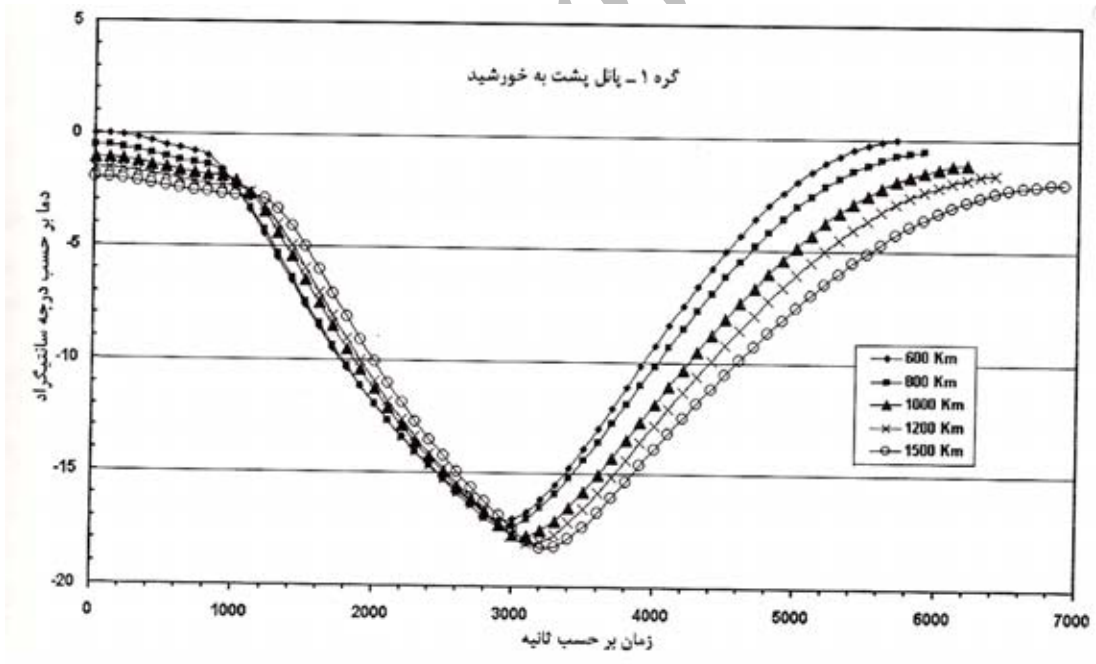
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		:		:				
*(Watt)	(Watt)	(Watt)	(Watt)	*(Watt)	(Watt)	(Watt)	(Watt)	(km)
/	/	/	/	/	/	/	/	
/	/	/	/	/	/	/	/	
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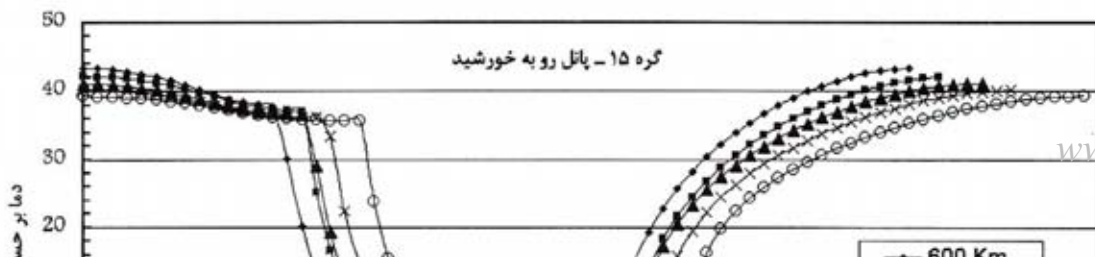
Anti Sun Side Sun Side

Anti Sun Side				Sun Side				
(Watt)	(Watt)	(Watt)	(Watt)	(Watt)	(Watt)	(Watt)	(Watt)	(km)
/	/	/		/	/	/	/	
/	/	/		/	/	/	/	
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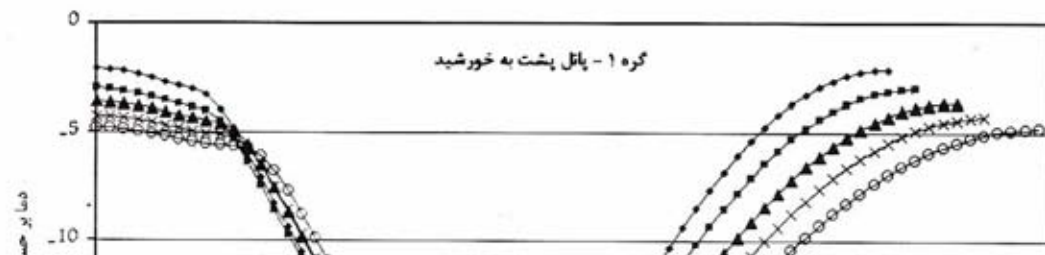
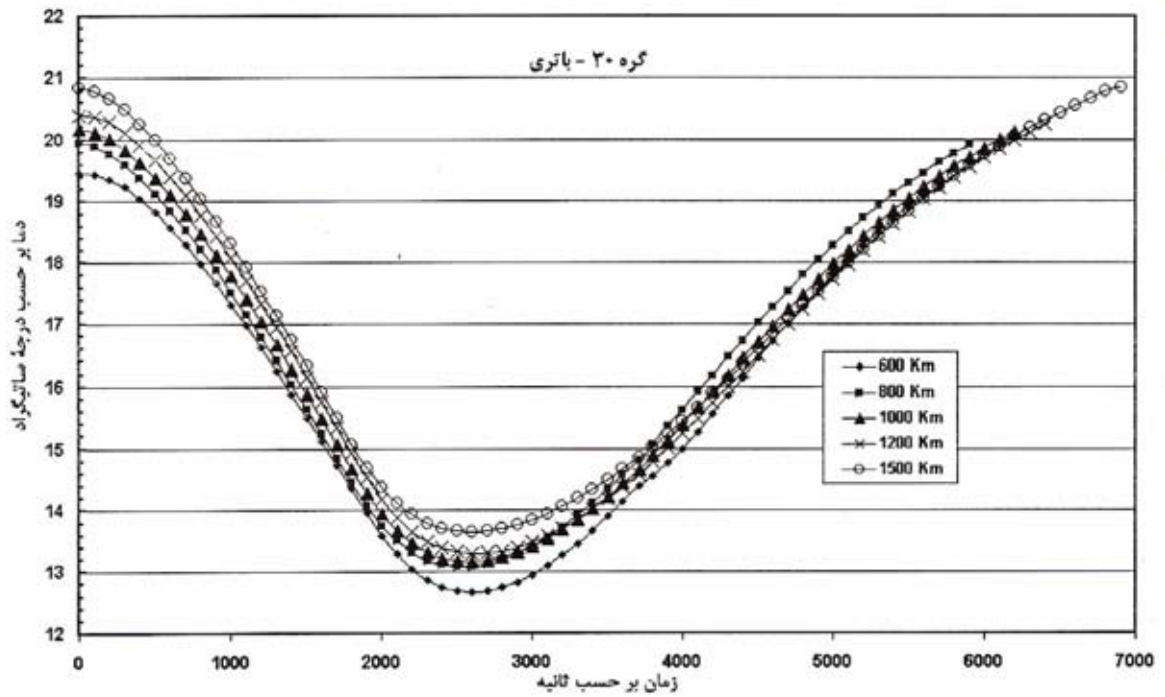


Anti Sun Side

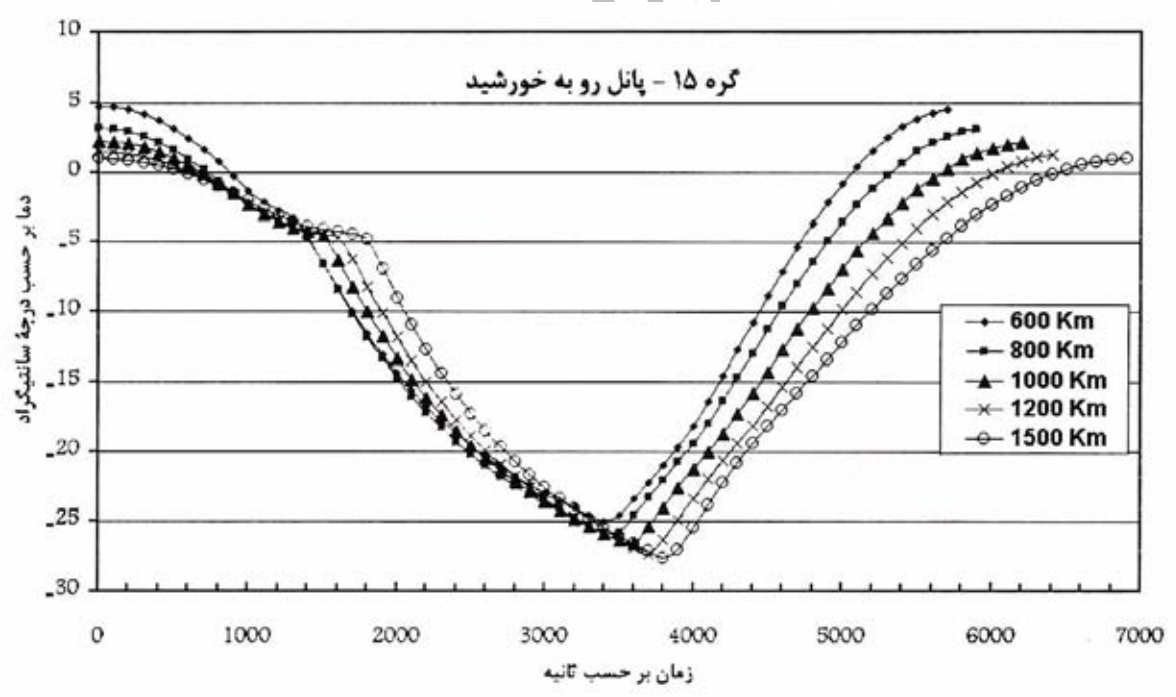
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Sun Side

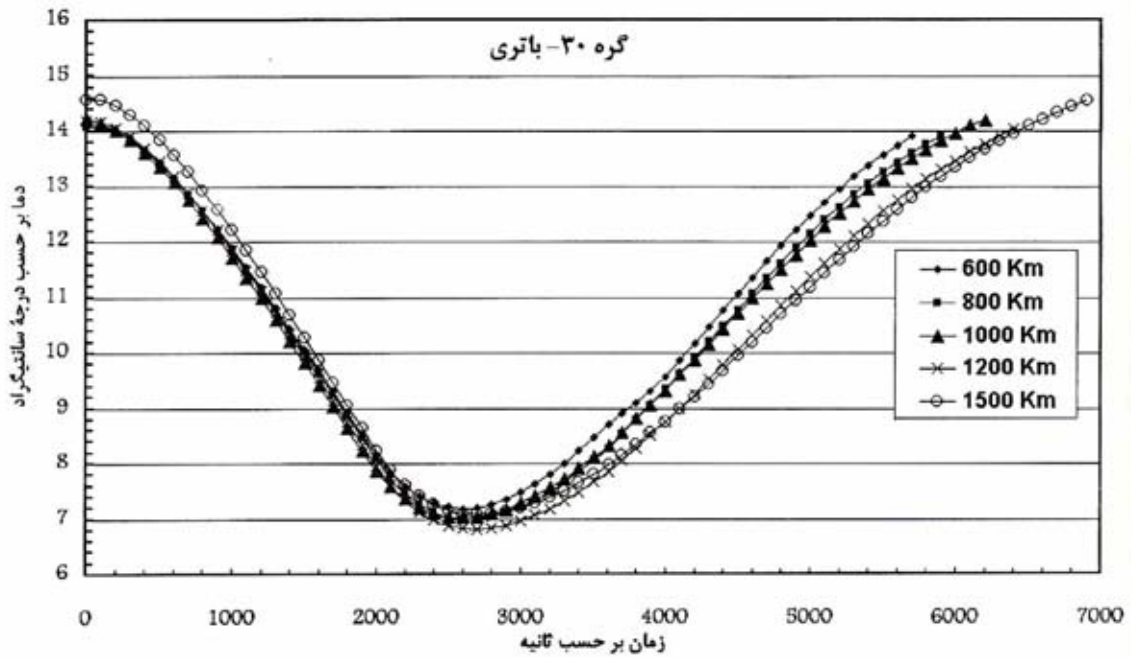


Anti Sun Side



Sun Side

()



Archive

() ()

() ()

m^2 i
 Km^2
 W/K j i
 j/kg k i

A_i
 a
 C_{ij}
 C_{pi}
 F_{12H}
 F_{12V}
 f_a
 f_E
 G
 h
 K

()

W/m^2
 Km
 W/m K

[5] Wertz, J. R., "Spacecraft Attitude Determination and Control", Kluwer Academic Publisher 1978.	Kg Sec	m_i P
" []	Km	R
"	$W/K^4 j_i$	RI
-	W/m^2	R_{ij}
[7] Ghassemi, M., Kharati, M. "Design and Analysis of Passive Thermal Control System of a Small satellite Located in Low Earth Orbit", International Journal of Engineering Science, No 2, Vol. 12, Summer 2001.	K i	T_i
[8] Krishnaprakas, C.K., "Application of Accelerated Iterative Method for Solution of Thermal Models of Spacecraft", Journal of Spacecraft and Rocket, Vol. 32, No. 4, July-August 1995.	Sec	t
[9] Gilmore, D.G., "Satellite Thermal Control Handbook", The Aerospace Corporation Press, California 1994.	Km^3/s^2	α_s
" []	W/m^2K^4	β
"	W/m^2K^4	δ_s
"	W/m^2K^4	ε
"	W/m^2K^4	μ
"	W/m^2K^4	ν
"	W/m^2K^4	σ
"	W/m^2K^4	Ω
"	W/m^2K^4	Ω_s
"	W/m^2K^4	Ω_s

[11] Karam, R. D., "Satellite Thermal Control for System Engineering", Vol. 181, Progress in Astronautics and Aeronautics, 1998.	[1] Killough, B. D., "A Simplified Orbit Analysis Program for Spacecraft Thermal Design" NASA Langley Research Center, Hampton VA, 1996.
" []	[2] Davidoff, M., "The Radio Amateur's Satellite Handbook", Published by The American Radio Relay League, Newington, 1998.
[13] Ghasemi, M. Sabbagh, A., "Design and Analysis of Passive Thermal Control System of a Small Satellite Located in Low Earth Orbit", International Journal of Engineering Science, Iran University of Science and Technology, Number 2, Vol. 12, Summer 2001.	[3] Logsdon, T., "Orbital Mechanics Theory and Application", John Wiley & Sons, Printed in USA, 1988.

"Sun synchronors