

О некоторых особенностях оптимизации режимов электропитания термоэлектрических охладителей в составе фотоприемников.

¹ #. \$. \$&(*+- .0, ² 1.2. 3&5 .0(, ² #.#. #&. 6 .0

¹79 ; <# = «9=? ?&A.B», C.E*0(, 7.EEAG

²H\$? «7 C I», C.E*0(, 7.EEAG

7(EK&.EL&(B+BB.M K&(*LA*.M GO-G+LEG ONO.& L+&6.P-+*L&AR+E*.S. .T-(VAL+-G (IW?) V-G AEK.-YZ.O(BAG 0 E.EL(O+ [.L.K&A+6BA*((<=) K. L(*, B(ZNO(+6N6, 6(*EA6(-YBN6 K(&(6+L&(6, (A6+BB.: 0+-ARAB(6 6(*EA6(-YBNT L.*(I_{max}, B(K&G\+BAG U_{max}, K+&+K(V(L+6K+&(L]& ΔT_{max} A T. -.V.K&.AZO.VAL+-YB.ELA Q_{max}.

=&A PL. 6 A6++LEG 0 0AV], RL. I_{max} A U_{max} B+ GO-G_LEG K&+V+-YB. V.K]ELA6N6A K(&(6+L&(6A, (E..LO+LELO]_L &+\A6] &+(-AZ(`AA K+&+K(V(L+6K+&(L]& ΔT_{max} K&A]E-.0AA Q₀=0.

!(BB(G K&(*LA*(.0]E-.0-+B(L+6, RL. PLA 6(*EA6(-YBN+ K(&(6+L&N GO-G_LEG .EB.OBN6A P-+6+BL(6A EK+`A[A*(`AA IW? B(6+\V]B(&.VB. 6 &NB*+.

?VB(*. L+.&+LAR+E*A+ A P*EK+&A6+BL(-YBN+ AEE-+V.O(BAG K.*(ZNO(_L, RL. .KLA6(-YBN+ IW? V-G K&A6+B+BAG 0 <= A AT &+\A6N &(O.LN .K&+V+-G_LEG &GV. 6 [(*L.&.0 A]E-.0AM P*EK-](L(`AA. =&A AZO+ELB.M 0+-ARAB+ L+K-.0.S. E.K&.LA0-+BAG ELN*]+6.S. E <= L+K-.EO&(ENO(_ a+S. &(VA(L.&(A6+_LEG &(O.RA+ ZB(R+BAG I₀<I_{max} A U₀<U_{max}, *.L.&N+ .0+EK+RAO(_L B(AO.-++ O-(S.K&AGLBN+ &+\A6N P*EK-](L(`AA EAEL+6N «<=&(VA(L.&». =&A K&.RAT &(OBNT]E-.0AGT AZ VO]T IW? E .VAB(*.ON6A ZB(R+BAG6A I_{max} K&+VK.RLAL+-YBN6 0 K-(B+ EBA\+BAG PB+&S.K.L&+O-+BAG GO-G_LEG IW? E O.-Y5 A6 ZB(R+BA+6 U_{max}.

b &(O.L+ K&A0+V+B K&A6+& .KLA6AZ(`AA &+\A6(P-+*L&.KAL(BAG VO]T*(E*(VB.S. IW? 0 E.EL(O+ 64-K-. a (VB.S. <=.

b .KLA*.-P-+*L&.BB.M (KK(&(L]&+, &(O.L(_ a+M 0 E&+VB+0.-B.O.6 d"-VA(K(Z.B+, 0*- _R(_ a+6 (L6.E[+&B.+ .*B. 3-56*6, 0 *.L.&. 6 E.E&+V.L.R+B(0+E. 6(G V.-G EK+*L&(E-(O. B(S&+LNT L+-, E]EK+T.6 AEK.-YZ]_LEG [.L.K&A+6BA*A (<=), .T-(\V(+6N+ EK+`A(-YBN6A IW? [1]. 7(EE6.L&+BA+ B+*.L.&NT .E.O+BB.EL+M .KLA6AZ(`AA &+\A6.0 P-+*L&.KAL(BAG IW? 0 E.EL(O+ <= B+&(Z&NOB. EOGZ(B. E 6+\V]B(&.VB.M K&(*LA*.M AT L+TBAR+E*.M EK+`A[A*(`AA A .EB.ONO(+LEG B([A*(`AA L(* B(ZNO(+6NT K(&(6+L&.0, (

A6+BB.: 6(*EA6(-YBNT L.*(I_{max}, B(K&G\+BAG U_{max}, K+&+K(V(L+6K+&(L)& ΔT_{max} A T. -.V.K&.AZO.VAL+-YB.ELA Q_{max} [2]. =&A PL.6, 0.K&+*A 0+EY6(&(ET.\+6] 6B+BA_, &+\ A6N I_{max} A U_{max} .LB_VY B+ .K&+V+-G_L K&+V+-YB. V.K]ELA6NM &+\ A6 P-+*L&.KAL(BAG. =.E-+VBAM .K&+V+-G+LEG L+6K+&(L)&.EL.M*.ELY_ IW?. !+MELOAL+-YB., K&A P*EK-](L(`AA IW? +S. L+K-.ONV+-G_a(G K.0+&TB.ELY B+AZO+\B. K+&+S&+0(+LEG .LB.EAL+-YB. L+6K+&(L)&N .*&]\(_ a+m E&+VN T_{o.c.}. e]a+ELO]_L L(*A+ L+*)aA+ ZB(R+BAG L.*(A B(K&G\+BAG I_{np} A U_{np}, K&+ON5+BA+ *.L.&NT K&A0.VAL * EL.-Y ONE.*.M L+6K+&(L)&+ L+K-.ONV+-G_a+m K.0+&TB.ELA, RL. B(RAB(+LEG &(Z6GSR+BA+ K&AK.G, *.66]LA&]_ a+S. IW?, A, *(* E-+VELOA+ PL.S., &(ZOA0(+LEG B+S(LA0BNM K&.`+EE B(&]5+BAG+S. `+- .ELB.ELA.

" (*]*(Z(B. 0 &(O.L+ [2], [AZAR+E*AM E6NE- 6(*EA6(-YBNT K(&(6+L&.0 -+\ AL 0 E.0+&5+BB. V&]S.M .O-(ELA. b Z(OAEA6.ELA .L 0+-ARABN L+K-.0.M B(S&]Z*A B(IW? 0.Z6.\B(&+(-AZ(`AG E(6NT &(Z-ARBNT K+&+K(V.0 ΔT 6+\V] L+6K+&(L)&(6A L+K-.ONV+-G_a+m A L+K-.K.S-. a(_ a+m K.0+&TB.EL+M (T_z A T_x, E. .LO+LELO+BB.) 0 VA(K(Z.B+ 0...ΔT_{max}. =&A PL.6 &+\ A6 ΔT=0 &+SAEL&A&]+LEG, *.SV(Q=Q_{max}, (&+\ A6 ΔT=ΔT_{max} - K&A Q=0. b L. \+ 0&+6G, K&A K&.RAT &(OBNT]E-.0AGT &+(-AZ(`AG &+\ A6(ΔT_{max} 0.Z6.\B(L.-Y*. K&A B+*.L.&NT .KLA6(-YBNT ZB(R+BAGT I A U, *.L.&N+ A K. -]RA-A .O.ZB(R+BAG I_{max} A U_{max}. b B(EL.G a++ 0&+6G K&(*LAR+E*A OE+ .L+R+ELO+BBN+ A Z(&]O+\BN+ &(Z&(O.LRA*A IW?]*(ZNO(_L 0 EK+\A[A*(`AA B(EO._ K&.V]*`A_ ZB(R+BAG I_{max}, U_{max}, ΔT_{max} A Q_{max} K&A T_z =300" A V(0-+BAA .EL(L.RBNT S(Z.0 .*&]\(_ a+m E&+VN g 10⁻³ 66.&L.EL., K&A *.L.&.6 *.BO+*LA0B(G E.EL(0-G_a(G L+K-.0.M B(S&]Z*A B(IW? K&(*LAR+E*A .LE]LELO]+L.

b [2] L(*\+ K.*(Z(B., RL. L+K-.L+TBAR+E*AM (B(-AZ EAEL+6N «IW? + &(VA(L.&» K.ZO.-G+L E[.&6]-A&.0(LY K(&(V.*E(-YB.+ B(K+&ONM OZS-GV K.-.\+BA+: P-+*L&.KAL(BA+ IW? 0 &+\ A6+ I_{max} A U_{max} B+ K&.V]*LA0B.. 7(O.RA+ ZB(R+BAG I₀<I_{max} A U₀<U_{max}. V.-\BN ONLY L(*.ON, RL.ON .O+EK+RALY 0(\B+M5++]E-.0A+ P-+*L&.KAL(BAG:

$$\frac{d\Delta T}{dP_0} \geq R_p,$$

SV+ P₀=Q₀+W₀ - &(EE+A0(+6(G L+K-.0(G 6. a B.ELY, bL,

Q₀ - &(O.R(G T. -.V.K&.AZO.VAL+-YB.ELY IW?, bL,

W₀ - K.L&+O-G+6(G P-+*L&AR+E*(G 6. a B.ELY, bL,

R_p - L+K-.0.+E.K&.LA0-+BA+ &(VA(L.&,("/bL.

b L. \+ 0&+6G .R+BY R(EL. &(Z&(O.LRA*(6 IW? 0 *(R+ELO+ AET.VBNT V(BBNT V-G K&.*LA&.0(BAG, *&.6+ ZB(R+BAG T_{o.c.}, T_x A W₀ Z(V(_LEG OK.-B+ *.B*&+LBN+, .K&+V+-G+6N+ .E.O+BB.ELG6A .KLA*.-P-+*L&.BB.M (KK(&(L)&N, ZB(R+BAG U₀ A R_p. ?ONRB. PL. ONO(+L, *.SV(A6++LEG AEL.RBA* KAL(BAG (**]6]-GL.&B.S. LAK(, (L+K-.EO&(ENO(_ a AM &(VA(L.&

]\ + * .BEL&]*LAOB. .K&+V+-+B A]-]R5+BA+ +S. P[[+*LAOB.ELA B+ K&+VEL(0-G+LEG
 0.Z6. \BN6. !-G PL.S. E-]R(G &(EE6.L&A6 V.K. -BAL+-YBN+ *&AL+&AA ONO.&(B(AO. -++
 K&+VK.RLAL+-YB.S. IW? B(K&A6+&+ AZV+-AG < 7-1291.

- dET.VBN6A L+TBAR+E*A6A L&+O.O(BAG6A V-G ONO.&(IW? GO-G-AEY E-+V]_ a A+:
- .Oh+*L .T-(\V+BAG: K.V-. *(AZ [.L.EL+*-(E &(Z6+&(6A 7.7T4.0T0.3 66³ A
 V-AB.M [.L.R]OELOAL+-YB.S. P-+6+BL((< i W) 6.466.
- T_x K&A L+6K+&(L] &+ .*&] \ (_ a +M E&+VN $T_{o.c.}=293$ ", " - g 233
- $U_0, b - 3.5$
- $R_p, "/bL - 3.0$

"&. 6+ L.S., B+.OT.VA6. ON-.]R+ELY, RL. &(ER+LB(G 0+-ARAB(L+K-.K&AL.*.0 Q_0
 E.EL(0-G+L 0.170 bL.

?&A+BLA&]GEY B(V(BBN+ H\$? «7.EEAME*A+ 6(L+&A(-N A L+TB. -.SAA» («7C I»),
 S. C.E*O(, E&(OBA6 L+TBAR+E*A+ K(&(6+L&N VO]T B(AO. -++ K.VT.VG aAT V-G V(BB.S.
 E-]R(G IW?.

$$I(O-A \ (1 - E&(OBAL+-YBN+ L+TBAR+E*A+ K(&(6+L&N IW?$$

=(&(6+L&	IAK IW?	
	2C e06-041-12	2C e06-051-12
i AE-. *(E*(V.0	2	
e+R+BA+ 0+LOA L+&6.P-+6+BL(, 66 ²	0.6T0.6	
bNE.L(0+LOA L+&6.P-+6+BL(, 66	1.2	
i AE-. L+&6.P-+6+BL.0 0 0+&TB+6 *(E*(V+	12	14
i AE-. L+&6.P-+6+BL.0 0 BA \ B+6 *(E*(V+	29	37
".P[[A`A+BL *(E*(VA&.0(BAG	2.58	2.64
7(Z6+&N L+K-.K.S-. a (_ a +M K.0+&TB.ELA, 66 ²	4T7	

7(Z6+&N L+K-.ONV+-G _ a +MA&.A&.&*

J0+-AR+BBN6 RAE- . 6 L+&6 .P-+6+BL.0, IW? 2C e06-051-12 A6++L Oj -Y5A+ 0+-ARABN U_{max}
A Q_{max} .

b. .0a+ S.0.&G, *(\ VNM AZ &(EE6(L&A0(+6NT IW? T(&(*L+&AZ]+LEG, 0 L. 6 RAE-+,
E+&A+M L(* B(ZN0(+6NT B(S&]Z.RBNT Z(OAEA6 .EL+M $Q(\Delta T)$ A $U(\Delta T)$ *(* K&A ZB(R+BAGT I_{max} ,
L(* A K&A ZB(R+BAGT L. *($I < I_{max}$ (&AE]B. * 1).

7AE]B. * 1

WLA Z(OAEA6.ELA E.V+& \ (L 0 E+0+ OK. -B+ V.EL(L.RBN+ E0+V+BAG V-G
S&([AR+E*.S. K.EL&. +BAG V&]SAT T(&(*L+&AELA* IW?, ABL+&+E]_ aAT &(Z&(O.LRA*.0 <=
I(*, V-G E&(OBAL+-YBNT .`+B.* IW? K.EL&.A6 S&([A* $I(U)$ K&A $T_2=300"$ A $Q_0=0$ bL
(&AE]B. * 2).

7AE]B. * 2

bNGBA6, RL. K&A Z(V(BB.M 0+-ARAB+ $U_0=3.5$ b (L.R*(\$) V-G IW? LAK(2C e06-
041-12 $I_0=1.03$ \$ (&AE]B. * 2, L.R*(b), E. .L0+LEL0+BB., $W_0=3.605$ bL (&AE]B. * 3, L.R*(b'),
V-G IW? LAK(2C e06-051-12 $I_0=0.78$ \$ (&AE]B. * 2, L.R*(e) A $W_0=2.73$ bL (&AE]B. * 3,
L.R*(e'). b.EK. -YZ.0(05 AEY +a+ &(Z V(BBN6A &AE]B*(1, (L(* \ + 6+L.V. 6 S&([AR+E*.S.
VA[[+&+B`A&.0(BAG, K.EL&.A6 Z(OAEA6.ELA $\Delta T(W)$ A $R_p(W)$ (&AE]B. * 3) V-G V0]T LAK.0
IW? K&A $T_2=300"$ A $Q_0=0$ bL (L. +ELY *.SV($W_0=P_0$). bAVB., RL.]E- .0A+, B(*-(VNO(+6. + B(
L+K- .0.+ E.K&.LA0-+BA+ &(VA(L.&(V-G IW? 2C e06-041-12 \ +ELR+, R+6 V-G IW? 2C e06-
051-12: V-G IW? LAK(2C e06-041-12 []B*`AG $R_p(W)$ -+ \ AL BA \ + 0 *(\ V.M L.R*+ W. WL.
\ + EK&(0+V-A0. .LB.EAL+-YB. &(O.RAT L.R*(E6. &AE]B. * 3, L.R* A F A G).

7AE]B. * 3

=&A L(*AT]&.0BGT W_0 IW? LAK(2C e06-041-12 V. - \ +B &+(-AZ.0N0(LY $\Delta T=93"$
(&AE]B. * 3, L.R*(D), (IW? LAK(2C e06-051-12 - $\Delta T=87.5"$ (&AE]B. * 3, L.R*(E). I(*A6
.0&(Z. 6, B(K+&0NM OZS-GV, IW? 2C e06-041-12 A6++L K&+A6] a+EL0. K+&+V 2C e06-051-12,
L(* *(* K.Z0. -G+L V.ELARY ΔT B(5.5" 0. -Y5+. ?VB(*. PL. B+ E.0E+6 L(*.

= .L&+OAL+-+M IW? ABL+&+E]+L 0 *.B+RB.6 AL.S+ B+ $\Delta T=T_2-T_x$, (P[[+*LA0BNM
K+&+K(V L+6K+&(L]&N $\Delta T_3=T_{o.c.}-T_x$. ?R+OAVB., RL., R+6 0. -Y5+ W_0 , (, ZB(RAL, K&A Z(V(BB. 6
ZB(R+BAA R_p A K+&+S&+0 L+K- .EO&(ENO(_ a+S. &(VA(L.&(.LB.EAL+-YB. $T_{o.c.}$, L+6 6+BY5+
 ΔT_3 . d6+BB. E]R+L.6 PL.S. [(*L.&(A B+.OT.VA6. &(EE6(L&A0(LY 0.K&.E .
`+-+E. .0&(ZB.ELA K&A6+B+BAG L.S. A-A AB.S. LAK(IW?. b L(O-A`+ 2 K&A0+V+BN
E&(OBAL+-YBN+ &(ER+LBN+ V(BBN+ K. P*EK-](L(`A.BBN6 K(&(6+L&(6 .0.AT LAK.0 IW? E
&(VA(L.&. 6.

I(O-A` (2 - E&(OBAL+-YBN+ P*EK-](L(`A.BBN+ T(&(*L+&AELA*A IW? E

&(VLA(L.&. 6

=&(6+L&	IAK IW?	
	2C e06-041-12	2C e06-051-12
$T_{o.c.}$, "	293	
Q_0 , bL	0.170	
R_p , "/bL	3.0	
U_0 , b	3.5	
I_0 , \$	1.03	0.78
W_0 , bL	3.605	2.748
T_z , "	303.82	301.24
ΔT , K	82.0	77.5
ΔT_g , K	71.18	69.26
T_x , "	221.82	223.74

dZ &(EE6 .L&+BBNT V(BBNT, K&+VEL(O-+BBNT O L(O-A`+ 2, 6. \B. EV+- (LY ONO.V .
L.6, RL. .O(IW? &+(-AZ]_L K&A6+&B. .VAB(*.0]_ &(ZB.ELY L+6K+&(L]& \Delta T, A,
E. .LO+LELO+BB., T_x (&(Z-ARA+ E.EL(O-G+L OE+S. 1.92"). I+6 B+ 6+B+, IW? 2C e06-051-12
GO-G+LEG O. -++ K&+VK.RLAL+-YBN6, L(* (* K.L&+O-G+L K&A6+&B. B(24% P-+*L&AR+E*.M
6. aB.ELA 6+BY5+, R+6 IW? 2C e06-041-12. WL.L [(*L.& AS&(+L .R+BY O(\B]_ &. -Y, L(*
*(* *.6K-+*L]+6N+ L+K-.0AZ.&N, *(* K&(OA-. , A6+_L O *(R+ELO+ AEL.RBA*(KAL(BAG
(**]6]-GL.&B]_ O(L(&+_ A K.BA \+BA+ PB+&S.+6*.ELA <=]O+-ARA0(+L O&+6G
B+K&+&NOB.M &(O.LN L+K-.0AZ.&(A E.*&(a (+L *. -AR+ELO. A R(EL.L] &+S-(6+BLBNT &(O.L
K. +S. .OE-] \AO(BA_. "&.6+ L.S., K.BA \+BBNM K&+S&+O L+K-.EO&(ENO(_ a+S. &(VA(L.&(
O O. -Y5+M EL+K+BA]V.O-+LO.&G+L EK+\`A [A*+ P*EK-](L(`AA L+K-.0AZ.&(O `A*-AR+E*.6
&+\ A6+ <<0*-_R+B>> - <<ON*-_R+B>>. =&A PL.6 K.E-+ *(\V.S. ON*-_R+BAG <= Z(ER+L
OB.OY O.ZBA*(_ a+S. K.L.*(L+K-(O B(K&(O-+BAA .L K+&+S&+L.S. &(VA(L.&(* < i W +S.
L+6K+&(L]&(O L+R+BA+ *.&.L*.S. K&.6+\]L*(O&+6+BA (B+E*.-Y*. E+*]BV) 6. \+L
K&+ONEALY L+6K+&(L]&] $T_{o.c.}$ I.SV(K&A K.E-+V]_ a+6 0*-_R+BAA L+K-.0AZ.&(L+6K+&(L]&BNM]&.0+BY .T-(\V+BAG < i W O]V+L]\+ ON5+, R+6 K&A K&+VNV] a+6
0*-_R+BAA, RL., O EO. _ .R+&+VY,]T]V5 (+L [.L.R]OELOAL+-YBN+ K(&(6+L&N <= . I(*A6
.O&(Z.6, R+6 B+ZB(RAL+-YB++ K.L&+O-G+6(G 6. aB.ELY <= A, E. .LO+LELO+BB., K+&+S&+O
&(VA(L.&(.LB.EAL+-YB. $T_{o.c.}$ L+6 6+BY5+ O]V+L E*(ZNO(LYEG PL.L B+S(LA0BNM [(*L.& B(
P*EK-](L(`A.BBNT K(&(6+L&(T <= A *.6K-+*L]+6.S. L+K-.0AZ.&(.

dET.VG AZ ON5+AZ-. \+BBNT &(EE)\V+BAM, 6. \B. EV+- (LY ONO.V, RL. K&A
K&.RAT &(OBNT]E-.OAGT A B(K+&+V Z(V(BBNT ZB(R+BAGT U_0 A R_p AZ VO]T IW? E

VAB(*.0N6A ZB(R+BAG6A I_{max} K&+VK.RLAL+-YBN6 V-G *.6K-+*L.0(BAG <= GO-G+LEG IW? E
Oj -Y5 A6 ZB(R+BA+6 U_{max} .

1 AL+&(L]&(

1. \$&(*+- .0 #.\$., C(SB]5+0E*AM b.7., eA0+B*.0(b.9., I&.A`*AM d.C., "(Z(B`+0
#.\$.//=&A*-(VB(G [AZA*(. 2002. 1 2. e. 69.

2.