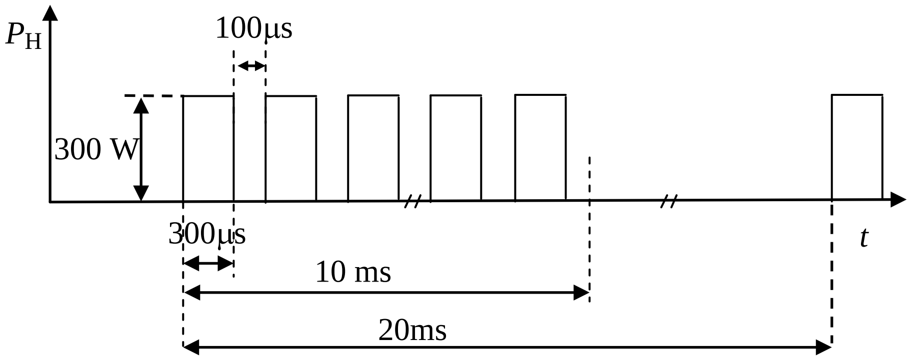
ELEC-E8421 Tehoelektroniikan komponentit

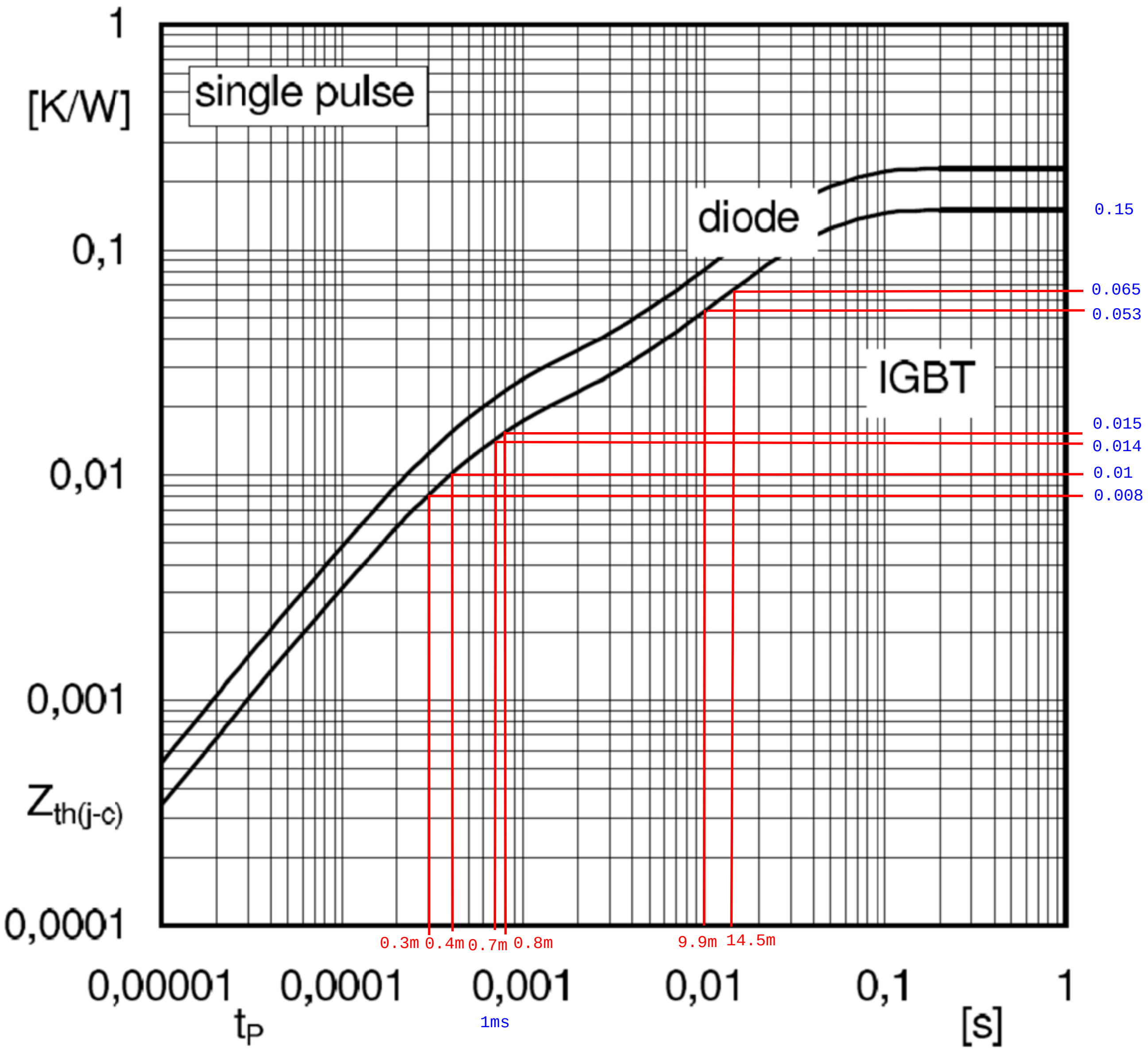
Harjoitus 6.

1. SEMiX223GB12Vs module IGBT losses are as shown in below picture, 20 ms continuous cycle with 10 ms of 25 identical pulses, lasting 300 us and between time of 100 us. Using accelerated superposition principle, determine the IGBT junction to case temperature at the end last pulse. Required figures and series is on the next page.



2. Disk type diode contact area diameter is 17 mm and losses are 205 W. The cooling case which is 2 sided should have a thermal resistance less than 0.26 K/W.

a) a) choose a cooling element using following datasheets
b) b) What is the minimum airflow required
c) c) what is the pressure difference between start and end of the cooling element
d) d) Calculate, which values you get for the thermal resistance when using volume and surface are based natural cooling experimental equations of 8.18 and 8.16 in the book, Compare values to the datasheets
(Note! All necessary measures are not visible in the datasheet, but you may use ruler to determine remaining metrics!)
e) e) using figure 8.11 define necessary airflow, compary to value in b). What causes the difference?



$R_{th(j-c)}$	per IGBT		0.14	K/W

$$Z_{th}(t) = R_1\left(1 - \exp\left(-\frac{t}{\tau_1}\right)\right) + R_2\left(1 - \exp\left(-\frac{t}{\tau_2}\right)\right) \qquad (4\text{-}2)$$

For SEMiX modules, the coefficients R_1, τ_1, and R_2, τ_2 can be determined using the data sheet values as given in Tab. 1-1.

		IGBT, CAL diode	**Thyristor, rectifier diode**
R_1	[K/W]	0.9 x $R_{th(j-c)}$	0.85 x $R_{th(j-c)}$
R_2	[K/W]	0.1 x $R_{th(j-c)}$	0.15 x $R_{th(j-c)}$
τ_1	[sec]	0.03	0.055
τ_2	[sec]	0.0005	0.0035

Tab. 1-1 Parameters for $Z_{th(j-c)}$ calculation using equation (4-2)

SEMiX® 3s

SEMiX223GB12Vs

Features

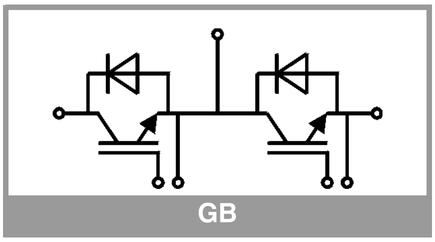
- Homogeneous Si
- $V_{CE(sat)}$ with positive temperature coefficient
- High short circuit capability
- UL recognised file no. E63532

Typical Applications*

- AC inverter drives
- UPS
- Electronic Welding

Remarks

- Case temperature limited to T_C=125°C max.
- Product reliability results are valid for T_j=150°C
- Dynamic values apply to the following combination of resistors:
  $R_{Gon,main}$ = 2,9 Ω
  $R_{Goff,main}$ = 2,9 Ω
  $R_{G,X}$ = 2,2 Ω
  $R_{E,X}$ = 0,5 Ω



GB

Absolute Maximum Ratings

Symbol	Conditions		Values	Unit
IGBT				
V_{CES}	T_j = 25 °C		1200	V
I_C	T_j = 175 °C	T_c = 25 °C	323	A
		T_c = 80 °C	246	A
I_{Cnom}			225	A
I_{CRM}	I_{CRM} = 3xI_{Cnom}		675	A
V_{GES}			-20 ... 20	V
t_{psc}	V_{CC} = 720 V V_{GE} ≤ 15 V V_{CES} ≤ 1200 V	T_j = 125 °C	10	µs
T_j			-40 ... 175	°C
Inverse diode				
I_F	T_j = 175 °C	T_c = 25 °C	263	A
		T_c = 80 °C	197	A
I_{Fnom}			225	A
I_{FRM}	I_{FRM} = 3xI_{Fnom}		675	A
I_{FSM}	t_p = 10 ms, sin 180°, T_j = 25 °C		1161	A
T_j			-40 ... 175	°C
Module				
$I_{t(RMS)}$	$T_{terminal}$ = 80 °C		600	A
T_{stg}			-40 ... 125	°C
V_{isol}	AC sinus 50Hz, t = 1 min		4000	V

Characteristics

Symbol	Conditions		min.	typ.	max.	Unit
IGBT						
$V_{CE(sat)}$	I_C = 225 A V_{GE} = 15 V chiplevel	T_j = 25 °C		1.85	2.3	V
		T_j = 150 °C		2.3	2.55	V
V_{CE0}		T_j = 25 °C		0.94	1.04	V
		T_j = 150 °C		0.88	0.98	V
r_{CE}	V_{GE} = 15 V	T_j = 25 °C		4.0	5.6	mΩ
		T_j = 150 °C		6.1	7.0	mΩ
$V_{GE(th)}$	V_{GE}=V_{CE}, I_C = 9 mA		5.5	6	6.5	V
I_{CES}	V_{GE} = 0 V V_{CE} = 1200 V	T_j = 25 °C		0.1	0.3	mA
		T_j = 150 °C				mA
C_{ies}	V_{CE} = 25 V V_{GE} = 0 V	f = 1 MHz		13.5		nF
C_{oes}		f = 1 MHz		1.33		nF
C_{res}		f = 1 MHz		1.33		nF
Q_G	V_{GE} = - 8 V...+ 15 V			2460		nC
R_{Gint}	T_j = 25 °C			3.33		Ω
$t_{d(on)}$	V_{CC} = 600 V I_C = 225 A V_{GE} = ±15 V $R_{G\ on}$ = 3.8 Ω $R_{G\ off}$ = 3.8 Ω di/dt$_{on}$ = 3200 A/µs di/dt$_{off}$ = 2000 A/µs du/dt$_{off}$ = 6600 V/µs	T_j = 150 °C		470		ns
t_r		T_j = 150 °C		72		ns
E_{on}		T_j = 150 °C		19.9		mJ
$t_{d(off)}$		T_j = 150 °C		665		ns
t_f		T_j = 150 °C		109		ns
E_{off}		T_j = 150 °C		27.2		mJ
$R_{th(j-c)}$	per IGBT				0.14	K/W

SEMiX® 3s

SEMiX223GB12Vs

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Remarks

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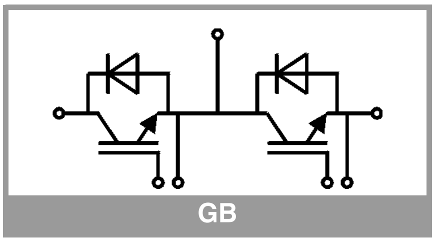


GB

Characteristics

Symbol	Conditions		min.	typ.	max.	Unit
Inverse diode						
$V_F = V_{EC}$	I_F = 225 A V_{GE} = 0 V chip	T_j = 25 °C		2.2	2.49	V
		T_j = 150 °C		2.1	2.4	V
V_{F0}		T_j = 25 °C	1.1	1.3	1.5	V
		T_j = 150 °C	0.7	0.9	1.1	V
r_F		T_j = 25 °C	3.6	3.9	4.4	mΩ
		T_j = 150 °C	4.7	5.4	5.9	mΩ
I_{RRM}	I_F = 225 A di/dt_{off} = 3400 A/µs V_{GE} = -15 V V_{CC} = 600 V	T_j = 150 °C		210		A
Q_{rr}		T_j = 150 °C		39.4		µC
E_{rr}		T_j = 150 °C		16.4		mJ
$R_{th(j-c)}$	per diode				0.23	K/W
Module						
L_{CE}				20		nH
$R_{CC'+EE'}$	res., terminal-chip	T_C = 25 °C		0.7		mΩ
		T_C = 125 °C		1		mΩ
$R_{th(c-s)}$	per module			0.04		K/W
M_s	to heat sink (M5)		3		5	Nm
M_t		to terminals (M6)	2.5		5	Nm
						Nm
w					300	g
Temperatur Sensor						
R_{100}	T_c=100°C (R_{25}=5 kΩ)			493 ± 5%		Ω
$B_{100/125}$	$R_{(T)}=R_{100}\exp[B_{100/125}(1/T-1/T_{100})]$; T[K];			3550 ±2%		K

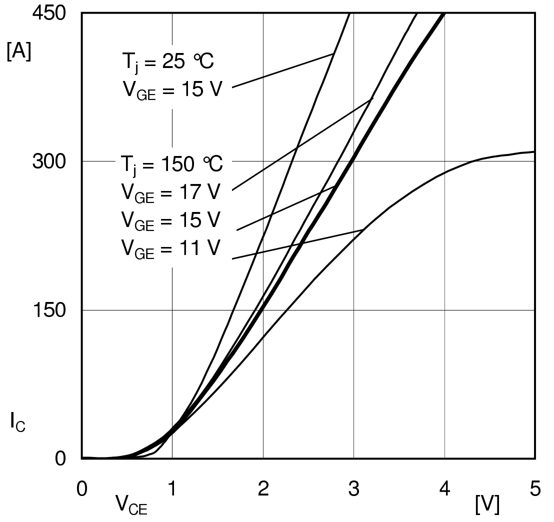


Fig. 1: Typ. output characteristic, inclusive $R_{CC'+ EE'}$

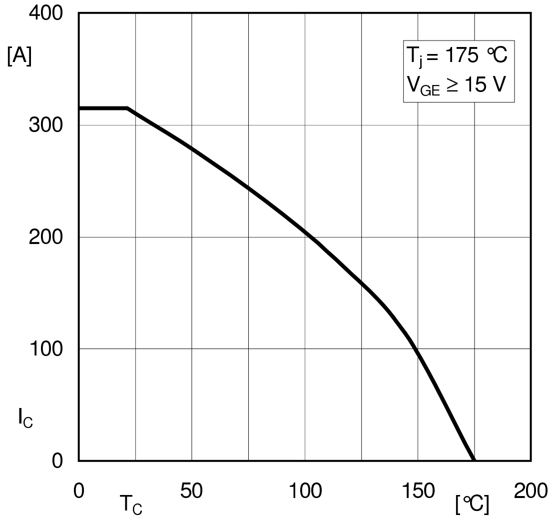


Fig. 2: Rated current vs. temperature $I_C = f (T_C)$

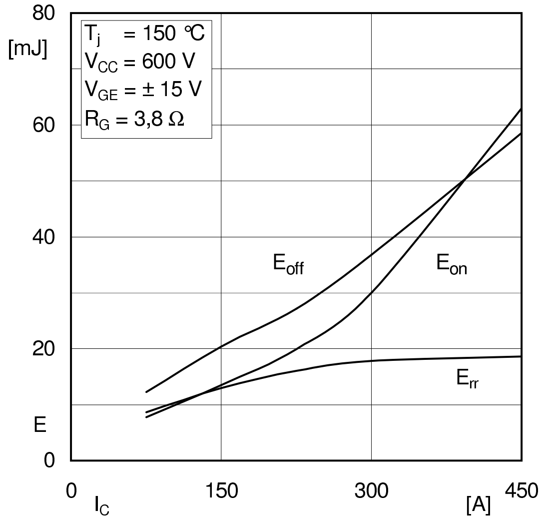


Fig. 3: Typ. turn-on /-off energy = f (I_C)

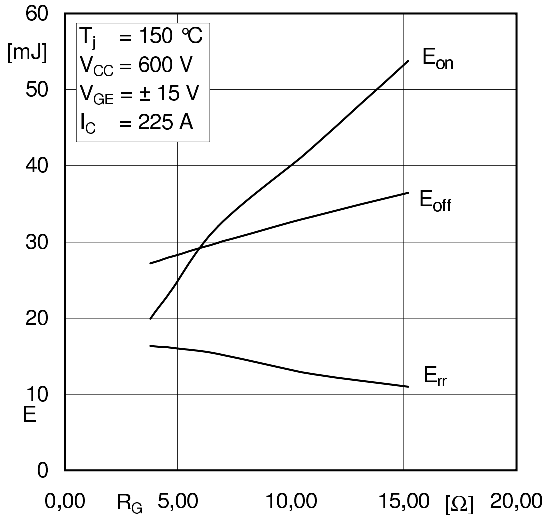


Fig. 4: Typ. turn-on /-off energy = f (R_G)

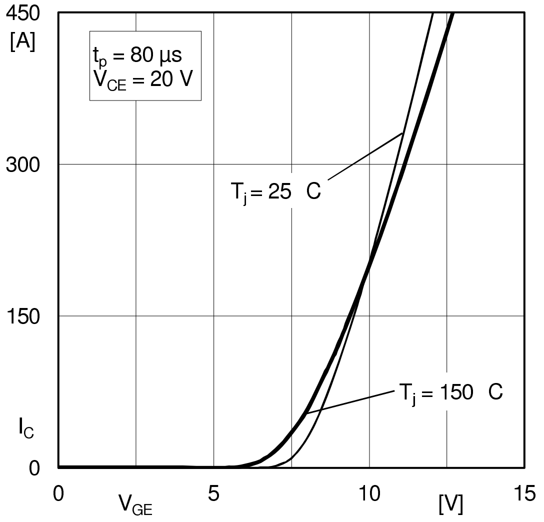


Fig. 5: Typ. transfer characteristic

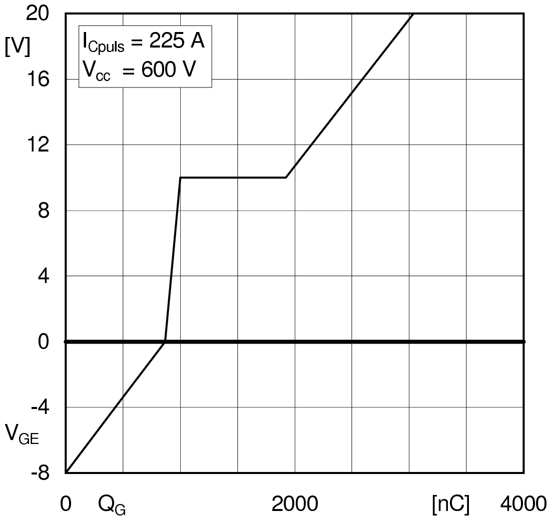


Fig. 6: Typ. gate charge characteristic

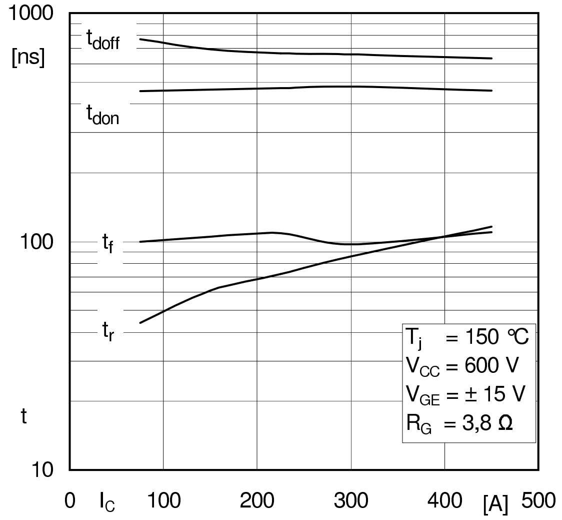


Fig. 7: Typ. switching times vs. I_C

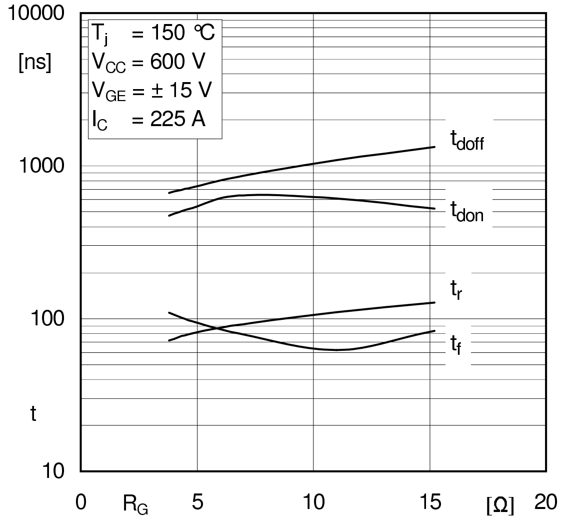


Fig. 8: Typ. switching times vs. gate resistor R_G

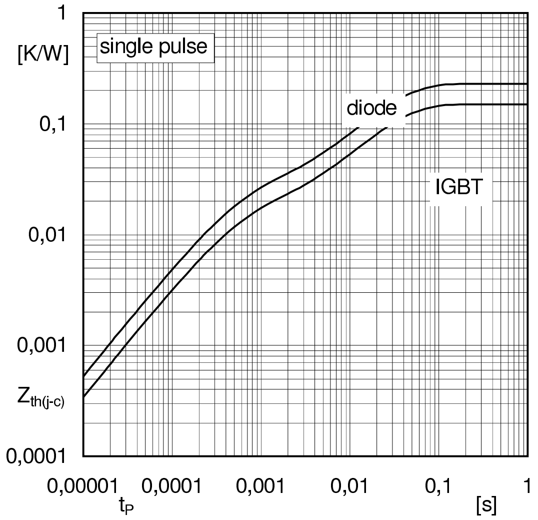


Fig. 9: Typ. transient thermal impedance

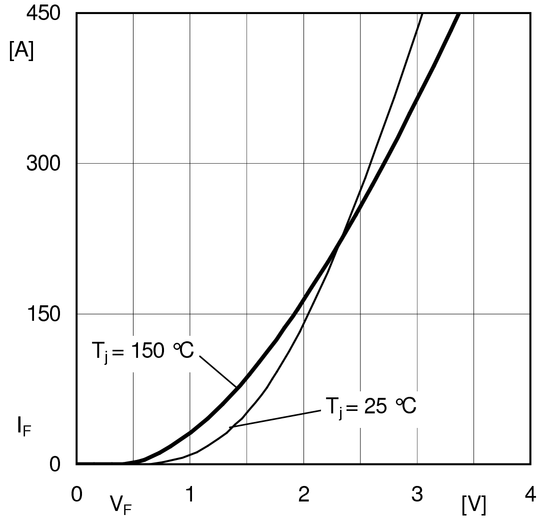


Fig. 10: Typ. CAL diode forward charact., incl. $R_{CC'+EE'}$

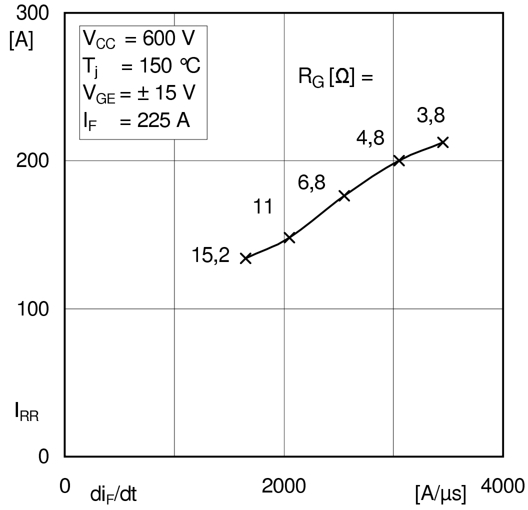


Fig. 11: Typ. CAL diode peak reverse recovery current

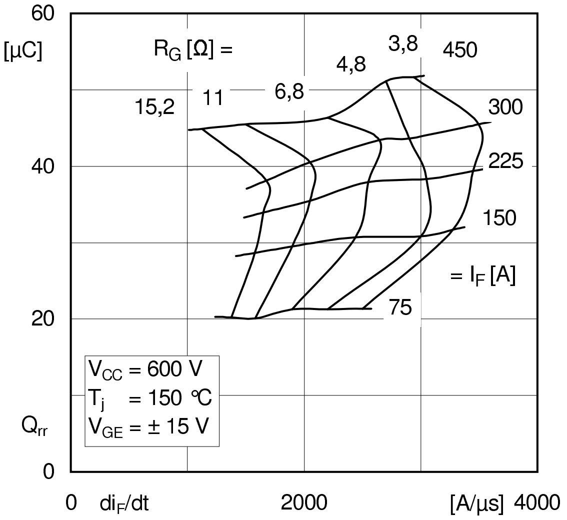
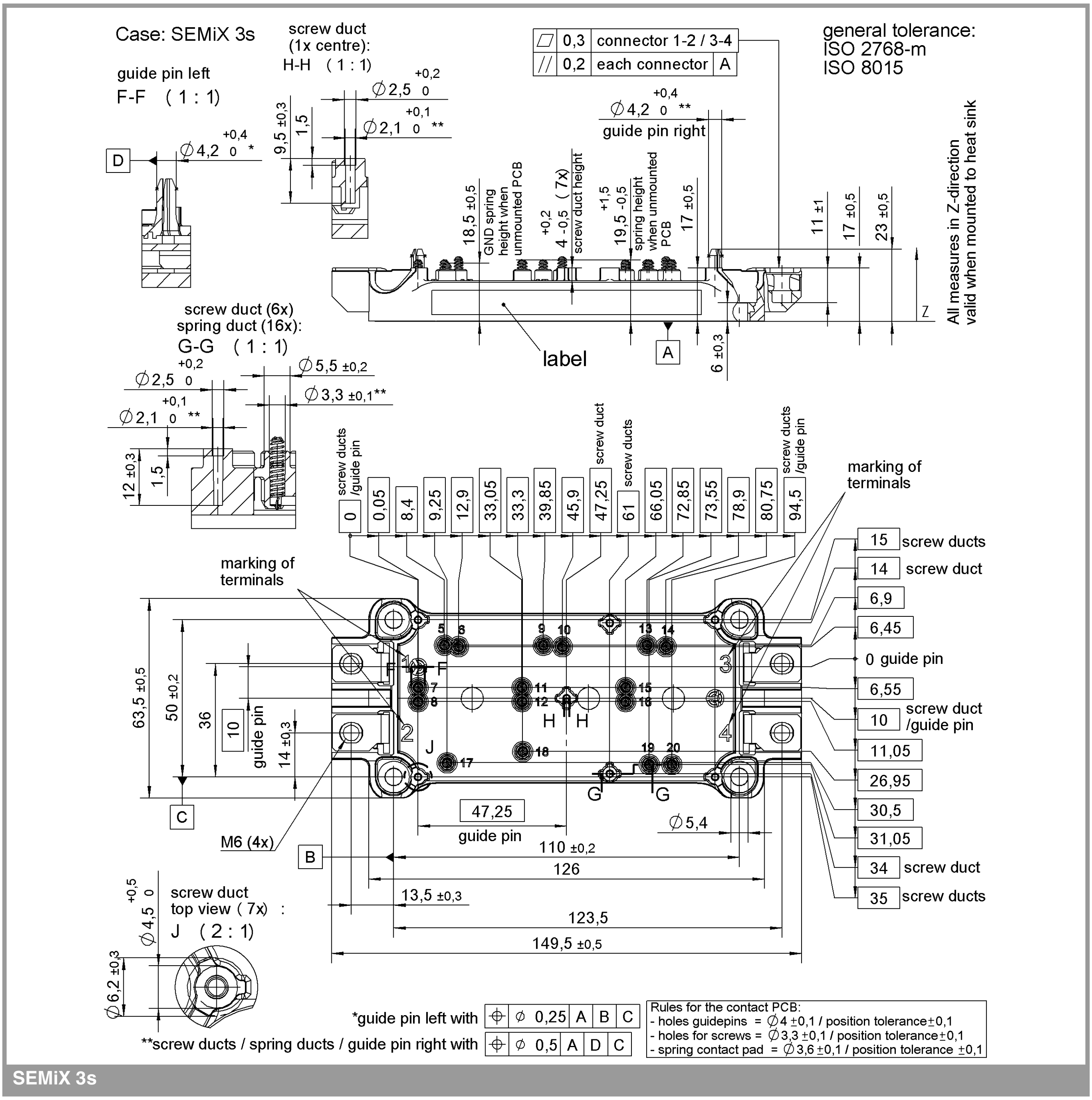
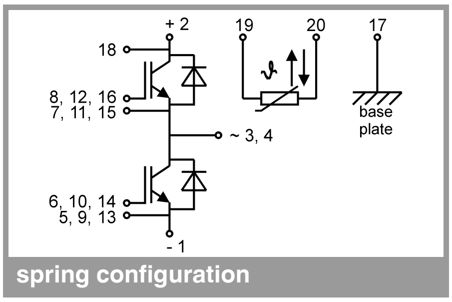


Fig. 12: Typ. CAL diode recovery charge



SEMiX 3s



spring configuration

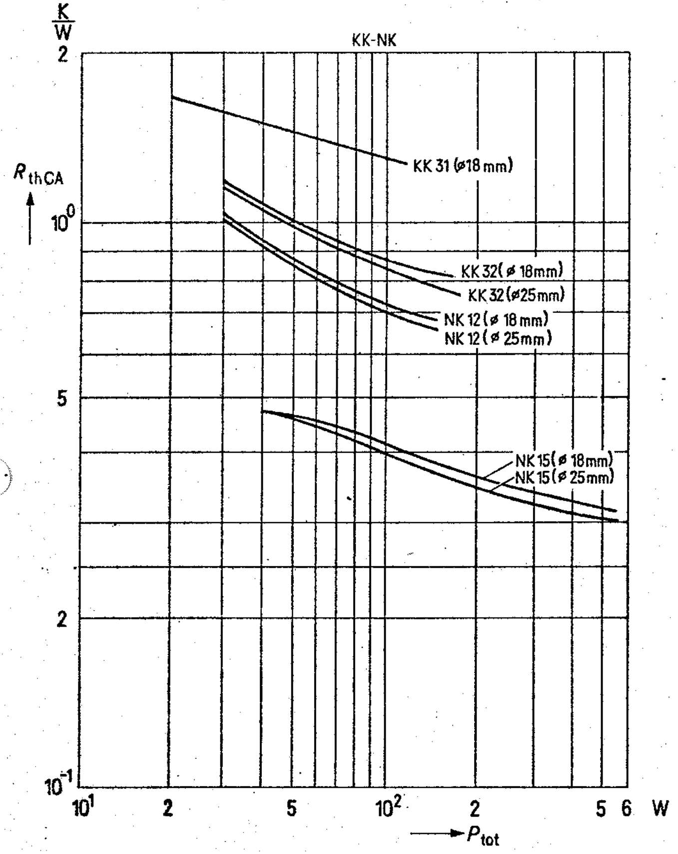
This is an electrostatic discharge sensitive device (ESDS), international standard IEC 60747-1, Chapter IX

* The specifications of our components may not be considered as an assurance of component characteristics. Components have to be tested for the respective application. Adjustments may be necessary. The use of SEMIKRON products in life support appliances and systems is subject to prior specification and written approval by SEMIKRON. We therefore strongly recommend prior consultation of our staff.

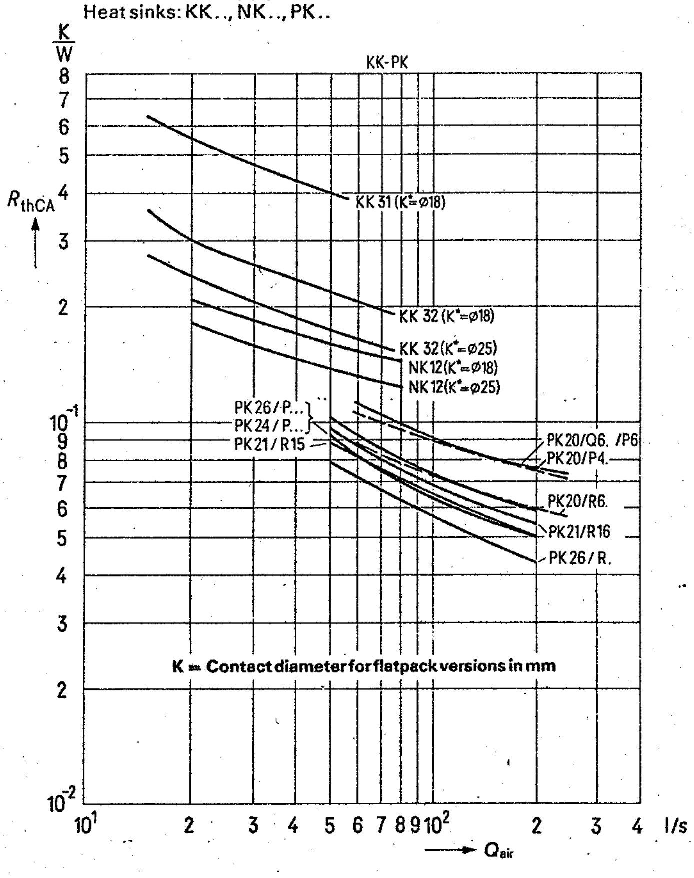
3

Heat sinks for disc components; air cooling

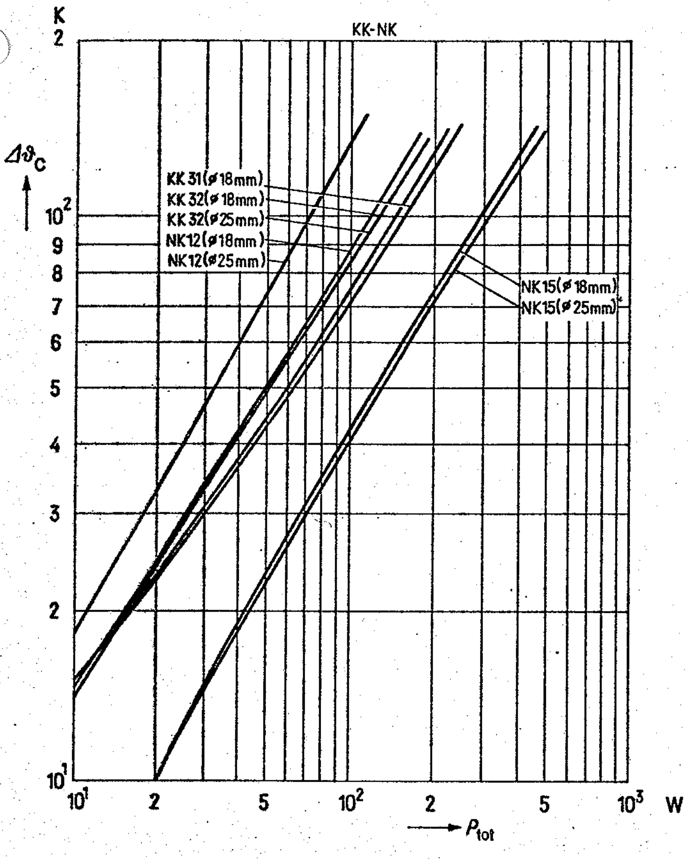
Thermal resistance R_{thCA}
versus power dissipation P_{tot}
Natural air cooling (S), arrangement in groups
Heat sinks: KK.., NK..



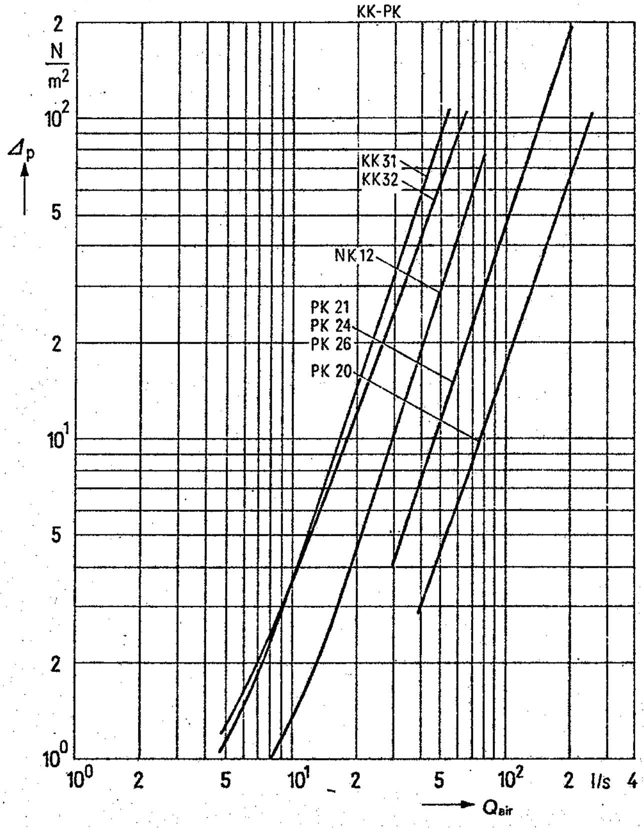
Thermal resistance R_{thCA}
versus cooling air quantity Q_{air}
Forced air cooling (F)
Heat sinks: KK.., NK.., PK..



Case overtemperature $\Delta\vartheta_c$
versus power dissipation P_{tot}
Natural air cooling (S), arrangement in groups
Heat sinks: KK.., NK..



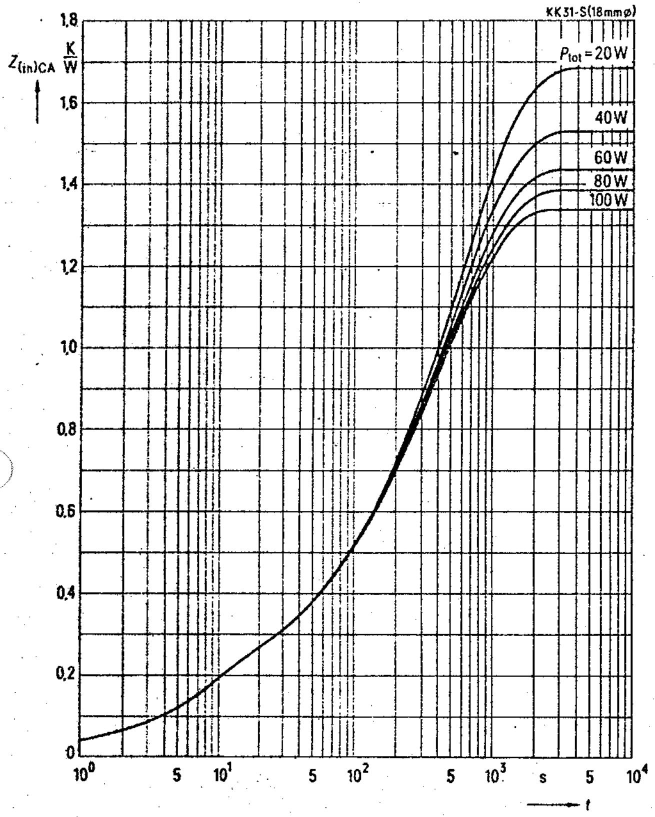
Pressure drop Δp
versus cooling air quantity Q_{air}
Forced air cooling (F)
Heat sinks: KK.., NK.., PK..



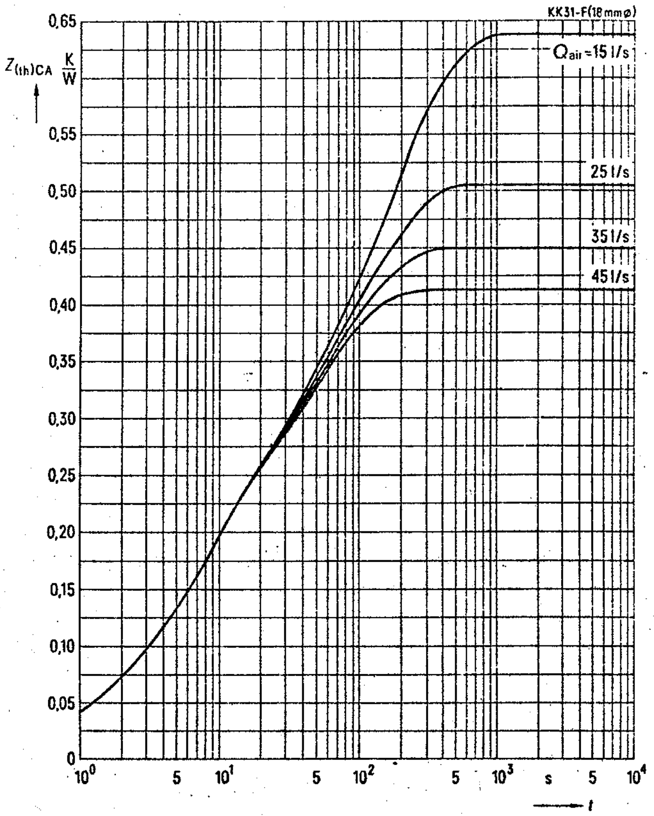
4

Heat sinks for disc components; air cooling

Transient thermal resistance
incl. heat transfer
Heat sinks KK 31 (K = 18 mm dia)
Natural air cooling (S)



Transient thermal resistance
incl. heat transfer
Heat sinks KK 31 (K = 18 mm dia)
Forced air cooling (F)



Transient thermal resistance
incl. heat transfer
Heat sinks KK 32 (K = 18 mm dia)
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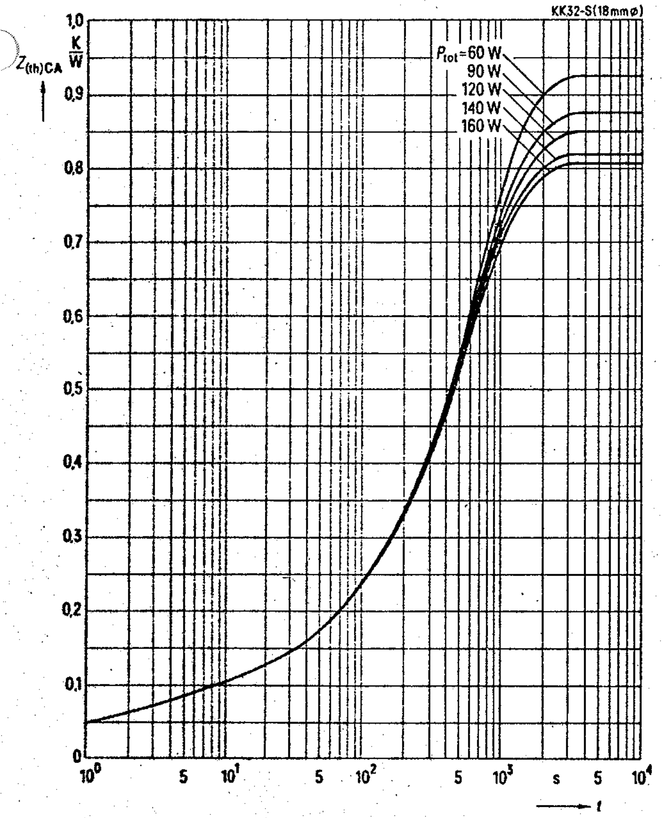
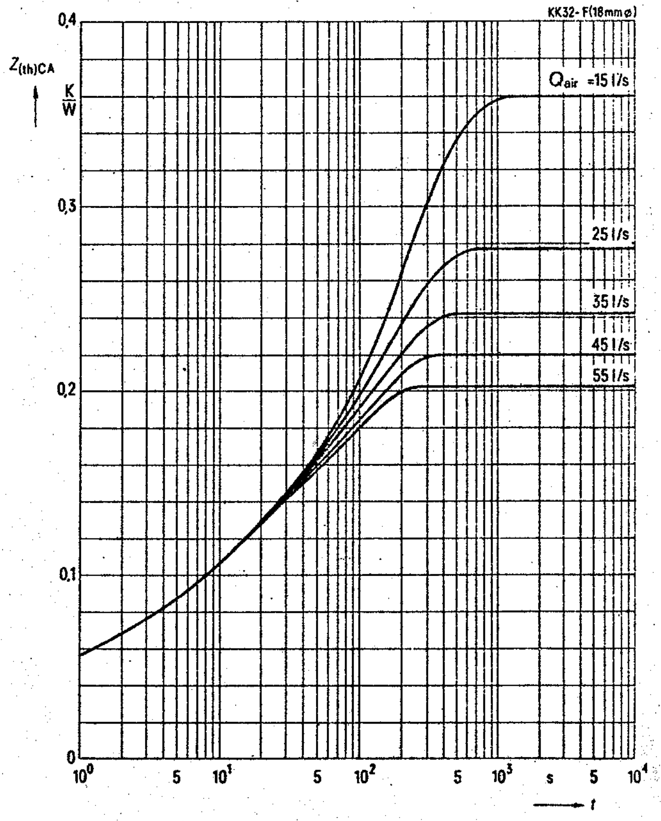


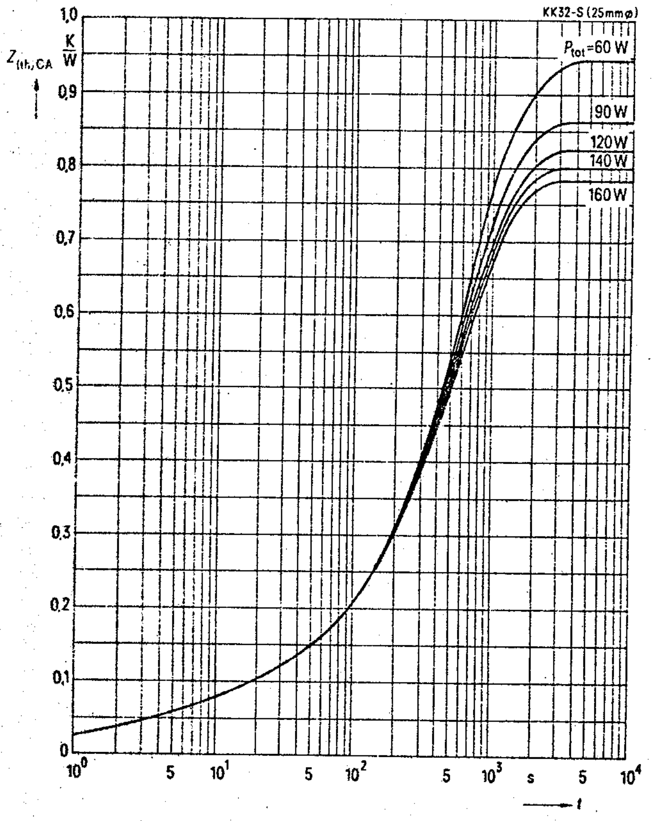
Transient thermal resistance
incl. heat transfer
Heat sinks KK 32 (K = 18 mm dia)
Forced air cooling (F)



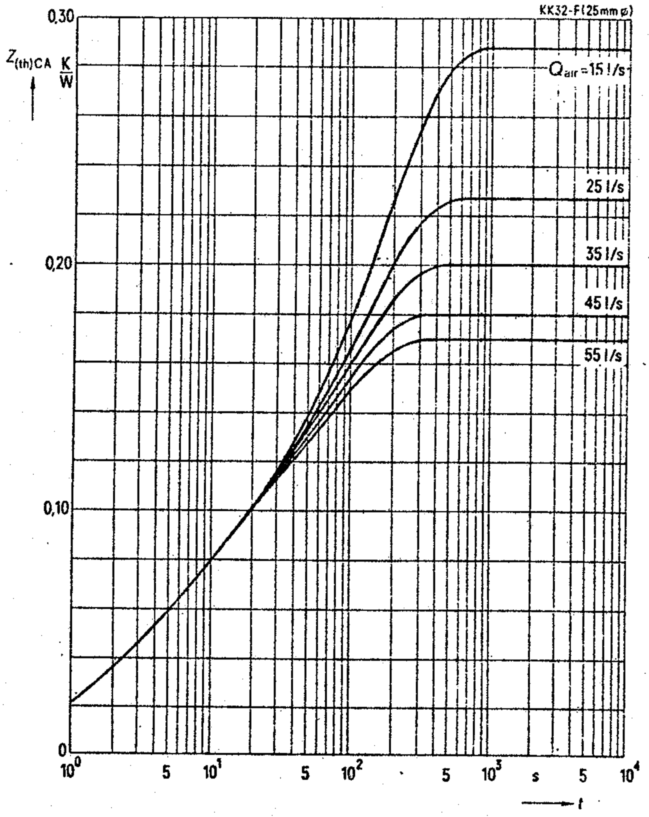
5

Heat sinks for disc components; air cooling

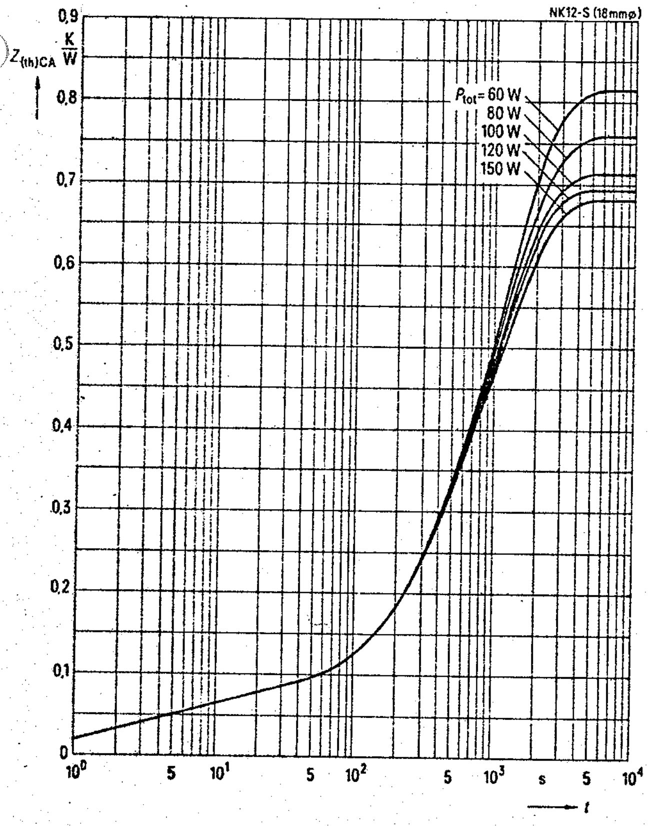
Transient thermal resistance
incl. heat transfer
Heat sinks KK 32 (K = 25 mm dia)
Natural air cooling (S)



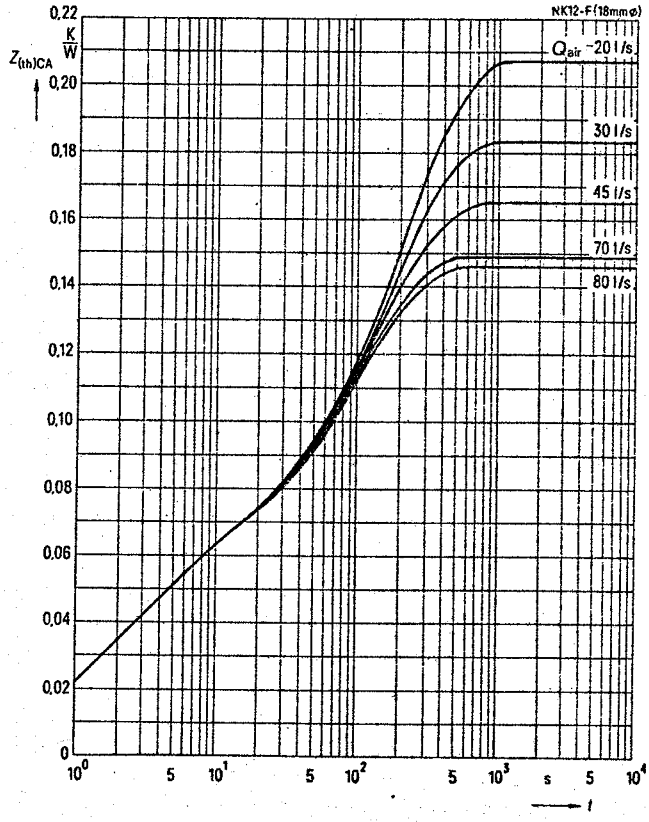
Transient thermal resistance
incl. heat transfer
Heat sinks KK 32 (K = 25 mm dia)
Forced air cooling (F)



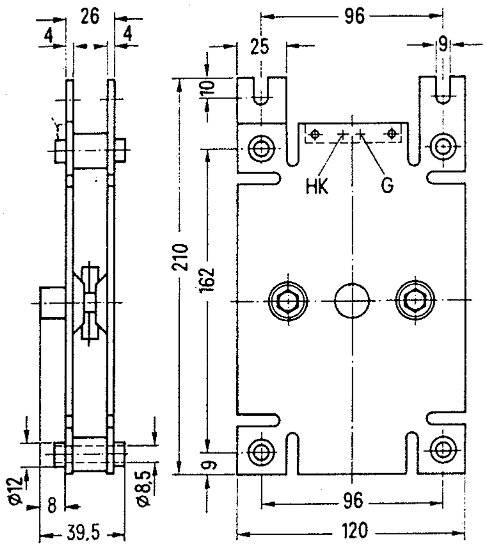
Transient thermal resistance
incl. heat transfer
Heat sinks NK 12 (K = 18 mm dia)
Natural air cooling (S)



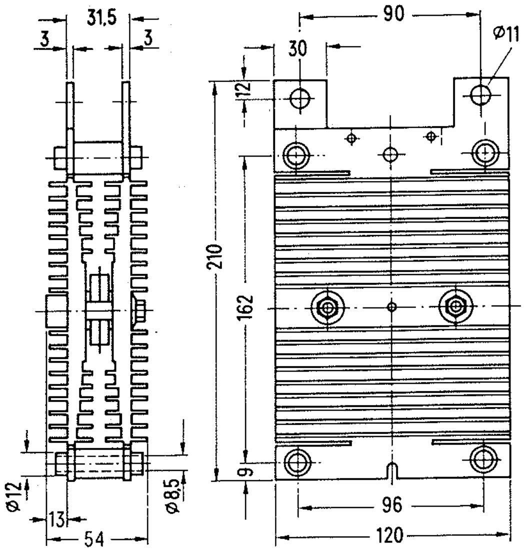
Transient thermal resistance
incl. heat transfer
Heat sinks NK 12 (K = 18 mm dia)
Forced air cooling (F)



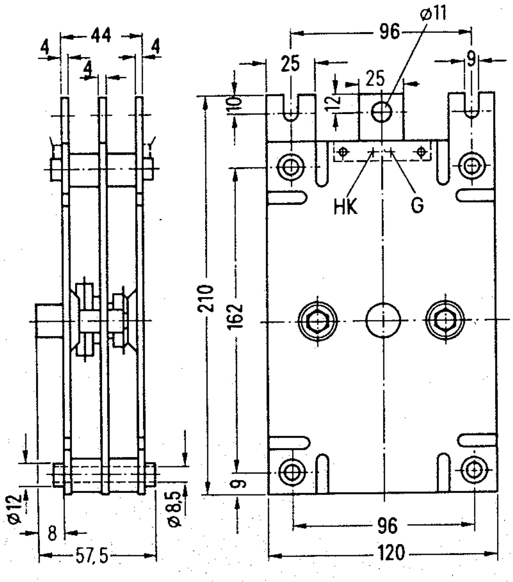
Heat sinks for disc components; air cooling



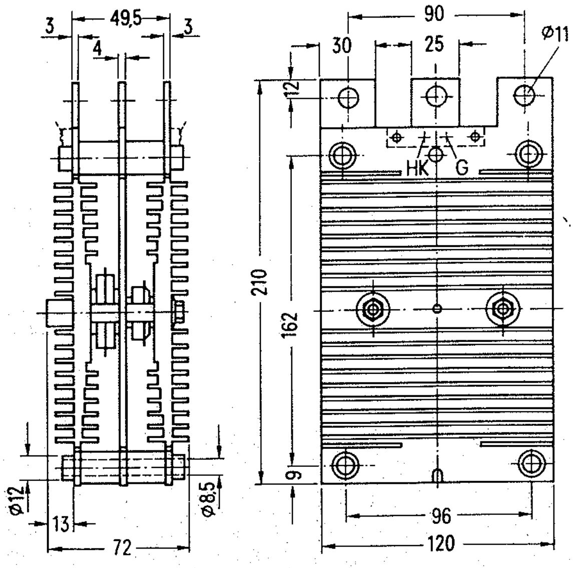
KK 31
Weight: 500 g



KK 32
Weight: 950 g

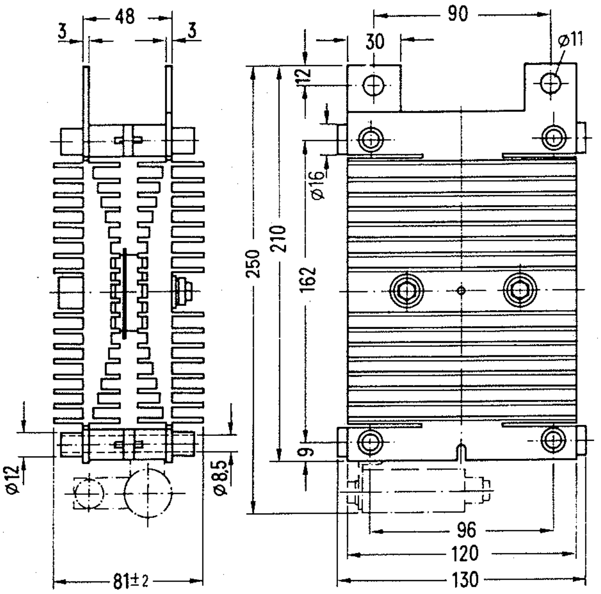


KK 33
Weight: 800 g

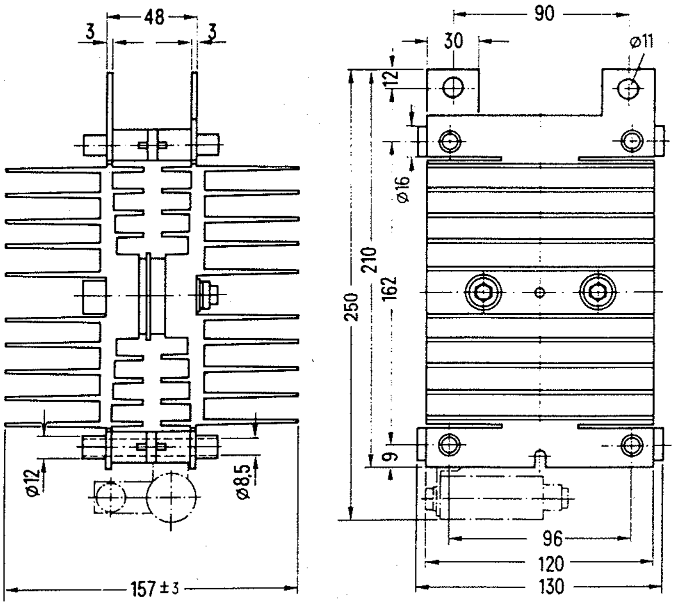


KK 34
Weight: 1200 g

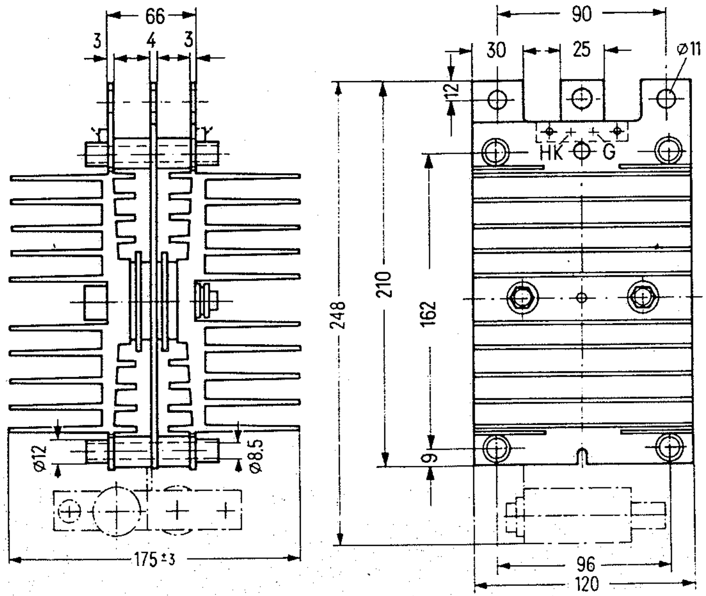
Heat sinks for disc components; air cooling



NK 12
Weight: 1800 g

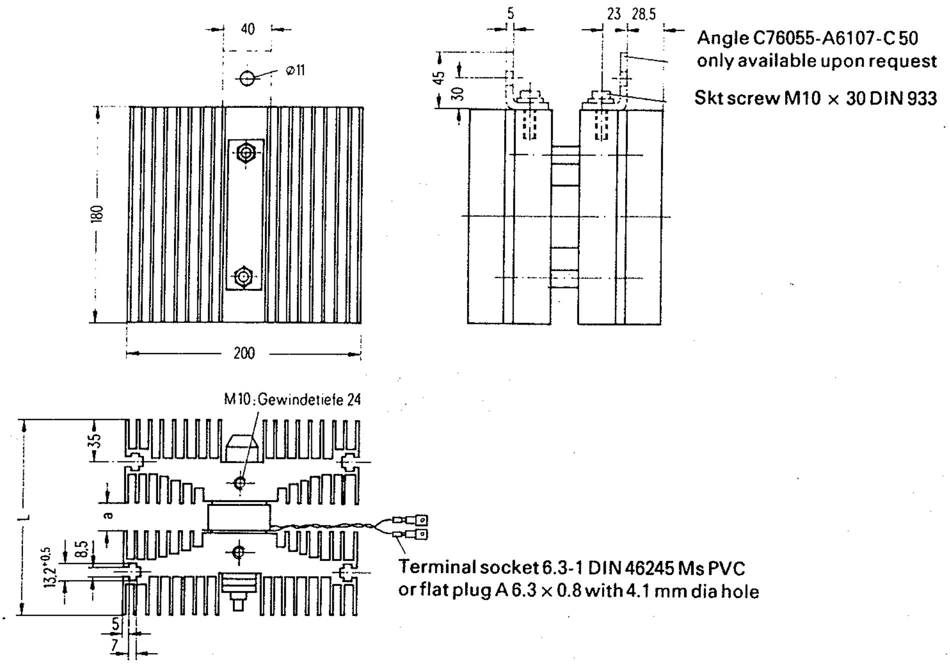


NK 15
Weight: 2400 g



NK 16
Weight: 2600 g

Dimensions in mm

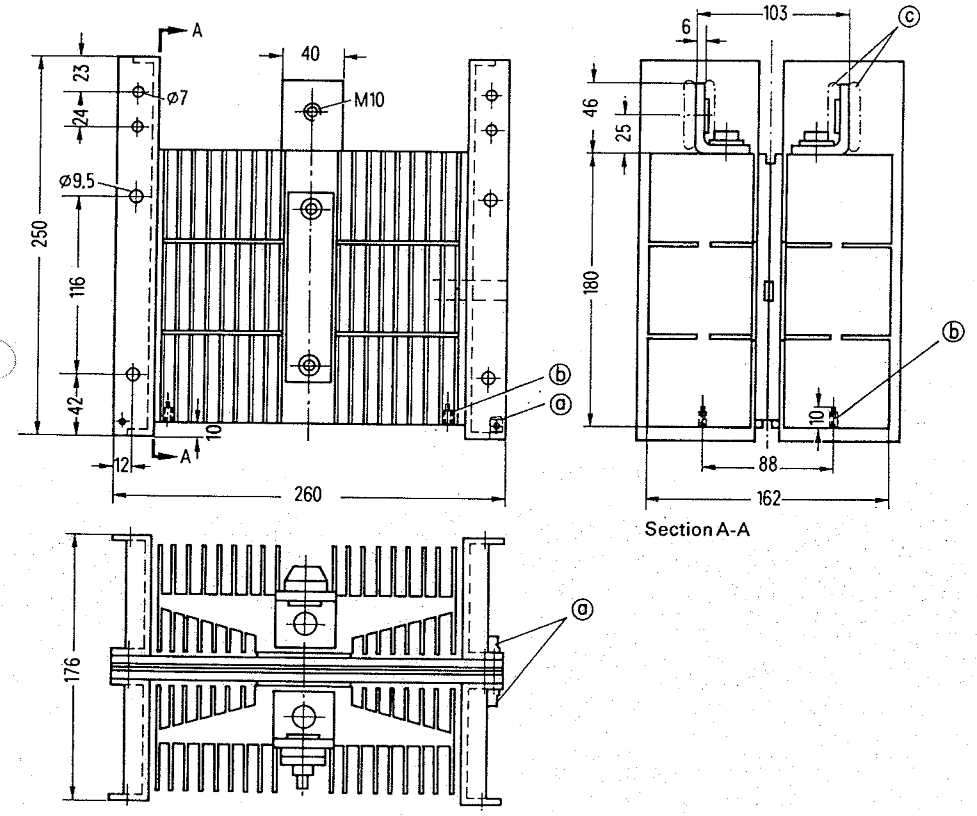


Angle C76055-A6107-C 50
only available upon request

Skt screw M10 × 30 DIN 933

Terminal socket 6.3-1 DIN 46245 Ms PVC
or flat plug A 6.3 × 0.8 with 4.1 mm dia hole

PK 20
Weight: 7,5 kg



Section A-A

PK 21
PK 24
PK 26
Weight: 11,5 kg

Dimensions in mm