SGS-THOMSON MICROELECTRONICS

APPLICATION NOTE

HEATSINK CALCULATION AND EXAMPLES

In many cases, GS-Rx and GSxTy-z modules don't require any additional cooling methods because the dimensions and the shape of the metal boxes were studied to offer the minimum possible thermal resistance case to ambient for a given module.
It should be remembered, that GS-R and GS-T modules are power devices i.e. products that deliver power and dissipate power and, depending on ambient temperature, an additional heat-sink or forced ventilation or both may be required to keep the unit within safe temperature range.
We would like here to eliminate a wrong parameter that has been plaguing the technical literature of power devices for 30 years: the operating ambient temperature specified among Absolute Maximum Rating.
The concept of operating ambient temperature is totally meaningless when we deal with power components, because the operating ambient temperature depends on how a power device is used.
What can be unambiguously defined is the maximum junction temperature of a power semiconductor device or the case temperature of a module. To prove this, let's consider the following example:

GS-R1005 at :
V_{in} = 24V I_o = 10 A P_o = 50 W $T_{casemax}$ = 75 °C

GS100T300-12 at :
V_{in} = 300 V I_o = 8 A P_o = 96 W $T_{casemax}$ = 70 °C

From data sheets we can get the respective efficiencies η and power dissipations

$$P_d = P_o \left(\frac{1}{\eta} - 1\right)$$

GS-R1005	$\eta = 0.83$	P_d = 10.2 W
GS100T300-12	$\eta = 0.84$	P_d = 18.3 W

In case of natural convection (no heat-sink or forced ventilation) the thermal resistance case to ambient and the maximum ambient temperature ($T_{ambMAX} = T_{Cmax} - R_{th} \bullet P_d$) will be:

GS-R1005
R_{th} = 7.5 °C/W T_{ambMAX} = 75-7.5•10.2=-1.5°C

GS100T300-12
R_{th} = 7.5°C/W T_{ambMAX} = 70-7.5•18.3=-62.25°C

As data show, the maximum operating ambient temperatures are a "non-sense" in the two cases, due to the fact that both devices are for use with an external heatsink.

In practice a designer must fix four preliminary values such as:

V_{in} = Input voltage

V_{out} = Output voltage

I_{out} = Output current

T_{amb} = Maximum ambient temperature at which the system must operate.

From these data, it is easy to determine whether an additional heat-sink is required or not and the relevant size i.e. the required thermal resistance. The step by step calculation is as follows:

1. Calculate output power:

$$P_O = V_O \bullet I_O$$

2. On data sheet, from V_o, V_{in}, I_o, the efficiency is obtained directly or by calculation:

$$\eta = \frac{P_O}{P_{IN}}$$

3. The actual power dissipation is given by:

$$P_d = P_O \left(\frac{1}{\eta} - 1\right)$$

4. The case temperature is calculated:

$$T_{CASE} = T_{AMBmax} + R_{th} \bullet P_d$$

(Rth is shown on data sheet)

5. If $T_{case} < T_{caseMAX}$ no external heat-sink is required

If Tcase > $T_{caseMAX}$ then proceed as follows.

6. Let's calculate what thermal resistance case to ambient is needed:

$$T_{TH(tot)} = \frac{T_{CASEmax} - T_{AMBmax}}{P_d}$$

This is the total thermal resistance i.e. the parallel of the module and external heat- sink thermal resistances.

7. The thermal resistance of the additional heat-sink is calculated:

$$R_{TH(HS)} = \frac{R_{THmodule} \bullet R_{TOT}}{R_{THmodule} - R_{TOT}}$$

As an example, let's consider two cases.
Conditions:

GS-R1005	GS100T300-12
$V_{in1} = 24$ V	$V_{in2} = 300$ V
$V_{o1} = 5$V	$V_{o2} = 12$ V
$I_{o1} = 2$A	$I_{o2} = 5$A
$R_{th1} = 7.5$ °C/W	$R_{th2} = 7.5$ °C/W
$T_{caseMAX}$=75°C	$T_{caseMAX}$=70°C

$T_{ambMAX} = 55$°C

1. Output powers:

$$P_{O1} = 5 \bullet 2 = 10\ W \quad P_{O2} = 12 \bullet 5 = 60\ W$$

2. From data sheet:

$$\eta_1 = 0.83 \quad \eta_2 = 0.84$$

3. Power dissipations:

$$P_{d1} = 10\ \left(\frac{1}{0.83} - 1\right) = 2.0\ W$$

$$P_{d2} = 60\ \left(\frac{1}{0.84} - 1\right) = 11.4$$

4. Case temperatures:

$$T_{C1} = 55 + 2.0 \bullet 7.5 = 70\ °C$$

$$T_{C2} = 55 + 11.4 \bullet 7.5 = 140.5\ °C$$

5. The GS-R1005 does not require heat-sink that is, on the contrary, required for GS100T300-12.

6. Total thermal resistance for GS100T300-12

$$R_{TH(TOT)} = \frac{70 - 55}{11.4} = 1.31\ °C / W$$

7. Required thermal resistance of heat-sink:

$$R_{TH(HS)} = \frac{7.5 \bullet 1.31}{7.5 - 1.31} = 1.58\ °C / W$$

The following table gives the thermal resistance of commercially available heat-sinks.

Manufacturer	Part Number	Rth °C/W	Mounting	Fastening
SGS-THOMSON	HS01	2.8	Vert.	Screw
THERMALLOY	6177	3	Horiz.	Screw
THERMALLOY	6152	4	Vert.	Screw
THERMALLOY	6111	10	Vert.	Adeshive
THERMALLOY	6155	4.5	Vert.	Screw
THERMALLOY	6601	5	Vert.	Screw
THERMALLOY	6176	4.5	Vert.	Screw
THERMALLOY	6320	1.5	Horiz.	Screw
ALUTRONIC	PR139	3	Vert.	Screw
ALUTRONIC	PR140	2	Horiz.	Screw
ALUTRONIC	PR159	2.5	Vert.	Screw
AAVID	60885	4.5	Vert.	Screw
AAVID	60660	1.5	Horiz.	Screw
AAVID	62355	3	Vert.	Screw
AUSTERLITZ	KS50	3	Vert.	Screw
AUSTERLITZ	KS100.3	2.5	Horiz.	Screw
FISCHER	SK18	3	Vert.	Screw
FISCHER	SK48	3	Vert.	Screw
FISCHER	SK16	1.5	Horiz.	Screw
FISCHER	SK52	2	Horiz.	Screw
FISCHER	SK07	4	Vert.	Adeshive
SGE Bosari	L30	3	Horiz.	Screw
SGE Bosari	LZ50	3	Vert.	Screw
SGE Bosari	SR50	6	Vert.	Adeshive
ASSMAN	V5280	2	Horiz.	Screw
ASSMAN	V5805	2	Vert.	Screw
ASSMAN	V5440	4	Vert.	Adeshive
ASSMAN	V5382	4	Horiz.	Screw
ASSMAN	V5460	3	Vert.	Screw
ASSMAN	V5510	3	Vert.	Screw