Exercise 3- Solution

1- From figure 3: $R_{DS(on)} = 1.02 * R_{DS(Nom)}$ when $I_D = 12$ A, and $T_j = 25$ °C

From numerical values $R_{DS(ON)}$= 0.5 ohms then $R_{DS(ON)} = 1.02 * 0.5 = 0.51$ ohms.

Symbol	Test Conditions		Characteristic Values (T_J = 25°C, unless otherwise specified) min.	typ.	max.	
V_{DSS}	V_{GS} = 0 V, I_D = 250 µA		600			V
$V_{GS(th)}$	V_{DS} = V_{GS}, I_D = 4 mA		2.0		4.5	V
I_{GSS}	V_{GS} = ±20 V_{DC}, V_{DS} = 0				±100	nA
I_{DSS}	V_{DS} = 0.8 • V_{DSS} V_{GS} = 0 V	T_J = 25°C T_J = 125°C			250 1	µA mA
$R_{DS(on)}$	V_{GS} = 10 V, I_D = 0.5 • I_{D25} Pulse test, t ≤ 300 µs, duty cycle d ≤ 2 %	15N60 20N60			0.50 0.35	Ω Ω

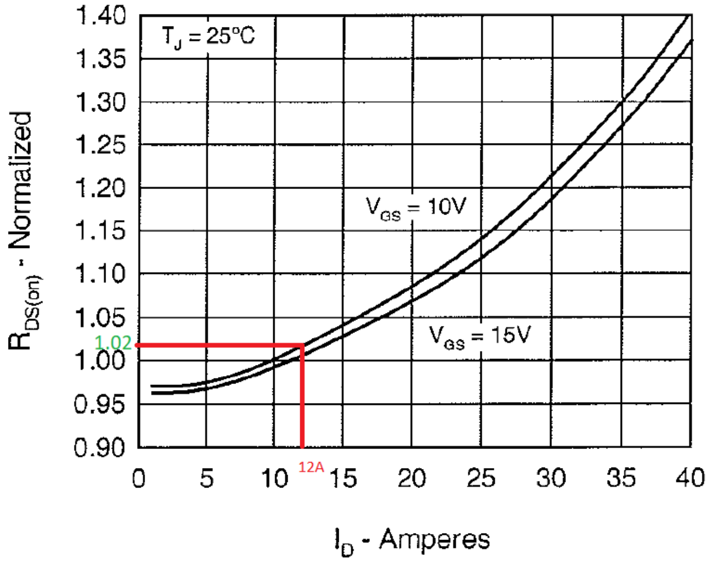
Applications
- DC-DC converters
- Synchronous rectification
- Battery chargers
- Switched-mode and resonant-mode power supplies
- DC choppers
- AC motor control
- Temperature and lighting controls
- Low voltage relays

Advantages
- Easy to mount with 1 screw (TO-247) (isolated mounting screw hole)
- Space savings
- High power density

IXYS reserves the right to change limits, test conditions, and dimensions. 91526E (4/99)

C1 - 214

Fig. 3 $R_{DS(on)}$ vs. Drain Current



From figure 4 @ temperature T_j = 150°C Thermal coefficient is 2.2 then:
$R_{DS(ON)} = 2.2 * R_{DS} = 2.2 * 0.51$ ohms = 1.12 ohms
Conduction loss energy can be written as:
$E_h = R_{DS} * I_D^2 * t_{on} = 1.12 * (12\text{ A})^2 * 20$ us = 3.23 mJ

Switching losses are not given in the datasheet. We may use triangular model based on rise and fall times. Assuming that voltage is constant and current is changing linearly. Therefore switching energy is:
$E_{h\_on} = t_r * U_{DS\_on} * I_D / 2 = 60$ ns * 360 V * 12 A / 2 = 0.13 mJ

Similarly for turn off losses:
$E_{h\_on} = t_f * U_{DS\_off} * I_D / 2 = 60$ ns * 500 V * 12 A / 2 = 0.18 mJ

Given F_{sw} >> 1 kHz we may assume steady state thermal resistance and average loss power. For lower frequencies, use figure 10.
$Ph_{avg} = (E_h + E_{h\_on} + E_{h\_off}) / T$ = (3.23 mJ + 0.13 mJ + 0.18 mJ) / 40 us = 88.5 W

Cooling element surface temperature:
$T_h = T_{jmax} - (R_{th(j-c)} + R_{th(c-k)})* P_{h\_avg} = 150° C - (0.42 K/W + 0.25 K/W) * 88.5 W$
$= 90.7° C$
Cooling element thermal resistance must be less than
$R_{th(h-a)} < (T_h - T_a) / P_{avg} = (90.7°C - 45°C) / 88.5 W = 0.52 K/W$

2- Losses as a function of thermal resistance coefficient
$P_{h\_avg} = P_{sw} + P_{conduction}$
$= (E_{h\_on} + E_{h\_off})/T + r_{ds}(Tj) * R_{DS(Id)}*I_d^2*t_{conduction} / T$
$= (0.13 mJ + 0.18 mJ) / 40 us + r_{ds}(Tj) * (0.51 ohm * (12 A)^2 * 20us) / 40 us$
$= 7.75 W + r_{ds}(Tj) * 36.7 W$
Now we have a line equation between P_h and T_j and we need to another describing line for the cooling system.

$P_{cool} = T_j - T_a / (R_{th(j-c)}+R_{th(c-k)} + R_{th(h-a)} = (T_j - 45°C) / (0.42 + 0.25 + 0.52 K/W)$
$= T_j / 1.19 K/W - 37.8 W$