

Mean Time To Failure = $1/\lambda$

Where,
 λ = Predicted failure rate

Case (i): Analysis for 45A IGBT

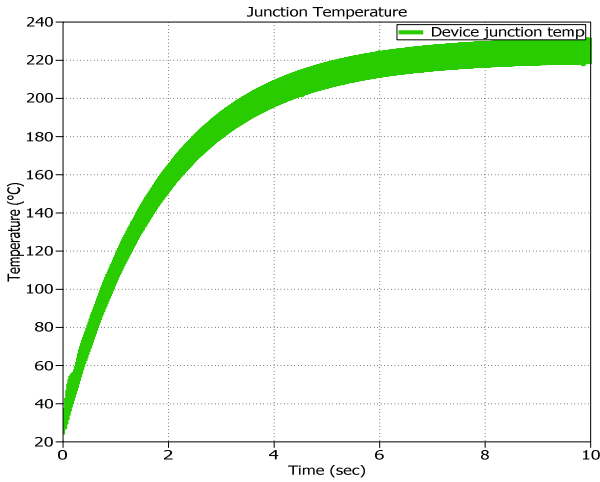


Figure 10. Junction temperature for 45A IGBT

Junction temperature for 400V & 45A IGBT module is 232.66°C. From equation 17, Reliability is evaluated as follows.

$$\begin{aligned} \pi_T(S) &= \exp \left[-1925 \left(\frac{1}{T_j+273} - \frac{1}{298} \right) \right] \\ &= \exp \left[-1925 \left(\frac{1}{232.66+273} - \frac{1}{298} \right) \right] \\ &= 14.1940 \end{aligned}$$

$$\begin{aligned} \lambda_p(\text{Switch}) &= \lambda_b * \pi_T * \pi_A * \pi_Q * \pi_E \\ &= 0.012 * 14.1940 * 10 * 5.5 * 6 \\ &= 56.208 \end{aligned}$$

$$\begin{aligned} \text{MTTF for IGBT (t)} &= 1/\lambda \\ &= 1/56.208 \\ &= 17790.87 \text{ Hours} \end{aligned}$$

$$\begin{aligned} \text{MTTF for inverter} &= 4 * \text{MTTF for IGBT} \\ &= 4 * 17790.87 \\ &= 71163.48 \text{ Hours} \end{aligned}$$

Case (ii): Analysis for 60A IGBT

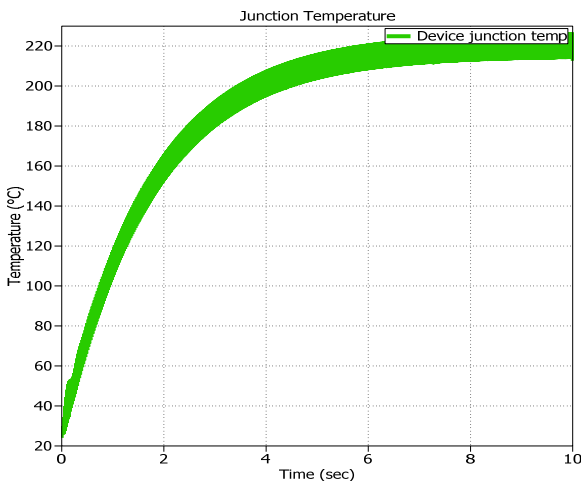


Figure 11. Junction temperature for 60A IGBT

Junction temperature for 400V & 60A IGBT module is 227.45°C. From equation 17, Reliability is evaluated as follows.

$$\begin{aligned} \pi_T(S) &= \exp \left[-1925 \left(\frac{1}{T_j+273} - \frac{1}{298} \right) \right] \\ &= \exp \left[-1925 \left(\frac{1}{227.45+273} - \frac{1}{298} \right) \right] \\ &= 13.6426 \end{aligned}$$

$$\begin{aligned} \lambda_p(\text{Switch}) &= \lambda_b * \pi_T * \pi_A * \pi_Q * \pi_E \\ &= 0.012 * 13.6426 * 10 * 5.5 * 6 \\ &= 54.0429 \end{aligned}$$

$$\begin{aligned} \text{MTTF for IGBT (t)} &= 1/\lambda \\ &= 1/54.0429 \\ &= 18509.98 \text{ Hours} \end{aligned}$$

$$\begin{aligned} \text{MTTF for inverter} &= 4 * \text{MTTF for IGBT} \\ &= 4 * 18509.98 \\ &= 74039.92 \text{ Hours} \end{aligned}$$

Case (iii): Analysis for 90A IGBT

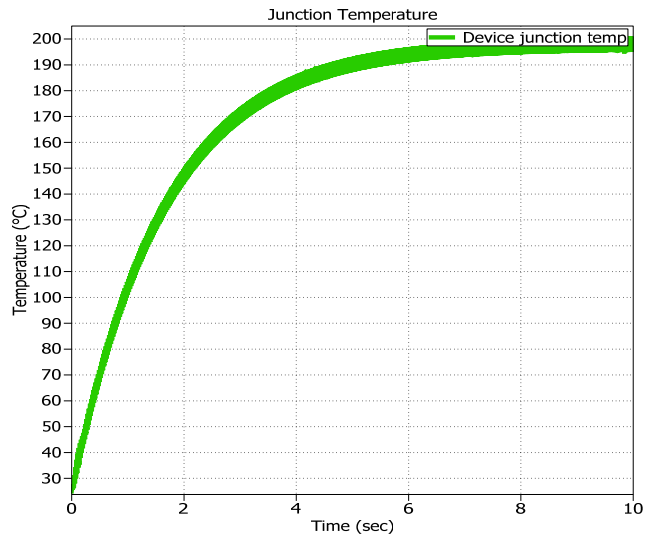


Figure 12. Junction temperature for 90A IGBT

The junction temperature for the 400V & 90A IGBT module is 227.45°C. From equation 17, Reliability is evaluated as follows.

$$\begin{aligned} \pi_T(S) &= \exp \left[-1925 \left(\frac{1}{T_j+273} - \frac{1}{298} \right) \right] \\ &= \exp \left[-1925 \left(\frac{1}{201.147+273} - \frac{1}{298} \right) \right] \\ &= 11.0210 \end{aligned}$$

$$\begin{aligned} \lambda_p(\text{Switch}) &= \lambda_b * \pi_T * \pi_A * \pi_Q * \pi_E \\ &= 0.012 * 11.0210 * 10 * 5.5 * 6 \\ &= 43.643 \end{aligned}$$

$$\begin{aligned} \text{MTTF for IGBT (t)} &= 1/\lambda \\ &= 1/43.643 \\ &= 22912.94 \text{ Hours} \end{aligned}$$

$$\text{MTTF for inverter} = 4 * \text{MTTF for IGBT}$$

$$= 4 * 22912.94$$

$$= 91651.76 \text{ Hours}$$

Case (iv): Analysis for 120A IGBT

The junction temperature for the 400V & 120A IGBT module is 198.8°C. From equation 17, Reliability is evaluated as follows.

$$\pi T (S) = \exp [-1925(1/(T_j+273)-1/298)]$$

$$= \exp [-1925(1/(198.8+273)-1/298)]$$

$$= 10.80$$

$$\lambda_p (\text{Switch}) = \lambda_b * \pi T * \pi A * \pi Q * \pi E$$

$$= 0.012 * 10.80 * 10 * 5.5 * 6$$

$$= 42.76$$

$$\text{MTTF for IGBT } (t) = 1/\lambda$$

$$= 1/42.76$$

$$= 23382.97 \text{ Hours}$$

$$\text{MTTF for inverter} = 4 * \text{MTTF for IGBT}$$

$$= 4 * 23382.97$$

$$= 93527.87 \text{ Hours}$$

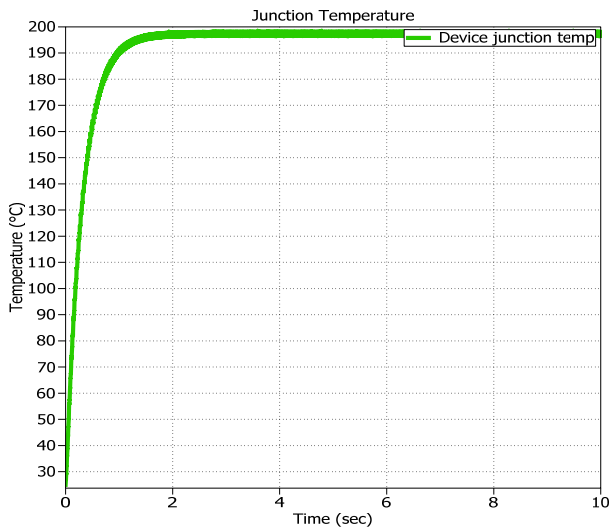


Figure 13. Junction temperature for 120A IGBT

Case (v): Analysis for 160A IGBT

The junction temperature for the 400V & 160A IGBT module is 186.71°C. From equation 17, Reliability is evaluated as follows.

$$\pi T (S) = \exp [-1925(1/(T_j+273)-1/298)]$$

$$= \exp [-1925(1/(186.71+273)-1/298)]$$

$$= 9.6378$$

$$\lambda_p (\text{Switch}) = \lambda_b * \pi T * \pi A * \pi Q * \pi E$$

$$= 0.012 * 9.6378 * 10 * 5.5 * 6$$

$$= 38.165$$

$$\text{MTTF for IGBT } (t) = 1/\lambda$$

$$= 1/38.165$$

$$= 26202.01 \text{ Hours}$$

$$\text{MTTF for inverter} = 4 * \text{MTTF for IGBT}$$

$$= 4 * 26202.01$$

$$= 104808.04 \text{ Hours}$$

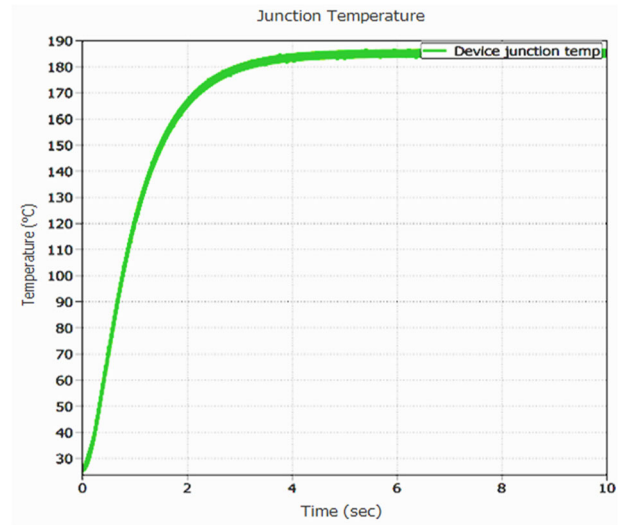


Figure 14. Junction temperature for 160A IGBT

Table 2. Reliability comparison for different IGBT

S.No	Ratings	Junction Temperature	Failure Rate	Life time of single IGBT in hours	Life time of Inverter in Years
1.	600 V 45 A IKW30N60T	232.66 °C	56.20	17790.87	8.12
2.	600 V 60 A IGW30N60H3	227.45 °C	54.02	18509.98	8.45
3.	600 V 90 A IGW50N60T	201.45 °C	43.64	22912.94	10.46
4.	600 V 120 A AIKQ120N60CT	198.8 °C	42.76	23382.97	10.67
5.	600 V 160 A AIKQ120N60T	186.71 °C	38.165	26202.01	11.96

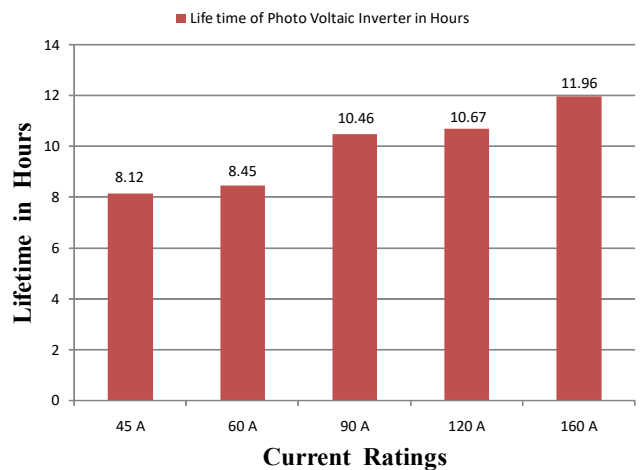


Figure 15. Life Time Vs Current Rating

From the above results, it can be concluded that the life span of the photo voltaic inverter circuit increases with an increase in the current ratings of the IGBT. This is due to a decrease in losses and junction temperature of an IGBT.

6. CONCLUSIONS

This paper describes the PV inverter reliability and performance under several current ratings that have been specified, the effect of junction temperature on lifetime is studied, and relevant lifetime is estimated. It has been proven that switching devices rated at different nominal currents have shown unequal thermal performances, leading to varied lifetime performances. The electro thermal modelling of power semiconductor modules has been thoroughly explained. The power loss modelling is based on look-up tables provided by the manufacturers in the datasheet that can be implemented in the PLECS Blockset in the Simulink environment so that the instantaneous switching and conduction losses can be calculated. On the other hand, the thermal modelling is based on a thermal equivalent network named the Foster model, whose parameters are also provided in the data sheets. For this study, the heat sink will be considered for each IGBT solution; it should be noted that an extended approach is to introduce the design variable of the heat sink parameter so the total cost of IGBT modules and cooling system can be considered. However, due to the constrained time frame, it is not included. Therefore, the PV inverter designers can choose the most reliable IGBT by this procedure.

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