1-10

THERMAL EQUIVALENT CIRCUIT OF TRAPATT - DIODE

P.K. CHATURVEDI & W.S. KHOKLE

Central Electronics Engineering Research Institute, PILANI (Rajasthan) INDIA.

SUMMARY

An attempt has been made to determine a thermal equivalent circuit of a TRAPATT diode. For the operation of TRAPATT diode in high efficiency mode, high current densities and power levels are required. A fraction of the power is dissipated as heat in the diode affecting the electrical performance of the device, by the mechanism called the thermal feed back. This electrical-thermal interaction occurs before the steady state is reached (i.e. during the initial transients), changing the parameters of the device. The above two processes have been studied theoritically and a thermal equivalent circuit representation using RC-network has been presented.

It is well known that in a TRAPATT-diode, a region of very high field (avalanching region) followed by high carrier density region (sheath), sweeps through the active region of the diode periodically. This period is followed by a low field, plasma period and the residual extraction period. In whole of the cycle $J_c.E$ product has been calculated, J_c being the particle current and E the electric field. It has been found that this product near avalanche region and sheath is much larger than any other region of the period. It may be assumed that most of this power is dissipated as heat.

On the application of bias at t = 0, the device starts getting heated and simultaneously the device parameters change which in turn vary the rise in temperature. The change may be in a direction to reach a stable operation or will become thermally unstable to reach a thermal runway. This behaviour has been studied and a thermal equivalent circuit has been derived, the elements of which are in terms of known and measurable quantities.

The equivalent circuit of the mounted device consists of a four port. Two being d.c. input and r.f. output ports, the rest of the two forming a feed back loop. The feed back loop consists of a series thermal R-C-Network.

The input power flows towards the heat sink, the flow of which depends upon the capacity and the temperature difference (with that of active region of the diode) of the heat sink. Therefore at t = 0, most of the power is fed back to the device, as the temperature difference is zero, thus raising the temperature in the device while for times much larger than the thermal time constant, all the power dissipated flows to the heat sink (assuming one directional heat flow and no radiation). Therefore the power dissipated goes to two thermal networks - the feed back network and the thermal impedence network.

This circuit with the appropriate elements explains the thermal behaviour of the TRAPATT-diode. Results of this thermal electrical analysis show that, the system is stable over a range of frequencies i.e. the dissipation in steady state for some frequencies are lower than that maximum which the heat sink can dissipate.