MOTOROLA INC.
SEMICONDUCTOR PRODUCTS DIVISION
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ZENER DIODE SLIDE RULE CALCULATOR

INSTRUCTIONS FOR SHUNT REGULATOR COMPUTATION

STEP 1: Calculation of Ballast Resistor, R_S

Scale A – Select $(V_{S\,MIN} - V_Z)$.
Scale B – Select $(I_L + I_Z)$ where I_L is load current in amperes and I_Z is minimum zener current 10% of I_L.
Register and read R_S in ohms on Scale C.

STEP 2: Calculation of $I_{Z\,MAX}$

Scale D – Select $(V_{S\,MAX} - V_Z)$.
Scale E – Select R_S calculated above.
Register and read $(I_{Z\,MAX} + I_L)$ on Scale F.
Subtract I_L and obtain $I_{Z\,MAX}$ in amperes.

STEP 3: Calculation of $P_{Z\,MAX}$, the Thermal Dissipation

Scale G – Select zener voltage, V_Z.
Scale H – Select $I_{Z\,MAX}$ from above.
Register and read $P_{Z\,MAX}$, in watts, on Scale I.

STEP 4: Calculation of Heat Sink Area

Scale J – Select maximum design ambient temperature.
Scale K – Select $P_{Z\,MAX}$ in watts, above calculated.
Register and read θ in °C/watt on Scale N. Add $(\theta_Z + \theta_1)$ and subtract from θ to obtain θ_S.
Enter θ_S on Scale N and read A_{HS}, the heat sink area, in square inches, on Scale M.

STEP 5: Calculation of Zener Voltage Change with Temperature Changes

Scale O – Select zener voltage, V_Z.
Scale P – Select anticipated temperature change ΔT, °C.
Register and read on Scale Q the regulated voltage change in millivolts.

A shunt regulator schematic, mathematical relations, table of symbols, and tables showing typical values of θ_1 and θ_Z are indicated on the front face and slide of the calculator.

To find the Motorola type number for any voltage and power reading, select the desired regulated voltage on scale R and then move the slide slightly until either one of the two adjacent vertical lines on scale S is aligned with the pointer at the bottom of the fixed scale. The type number for the various power types will appear in the windows.

SAMPLE CALCULATIONS

22 – 12 = 10 volts (A)
2.1 + .21 = 2.31 amps (B)
R_S = 4.33 ohms (Read C)

32 – 12 = 20 volts (D)
R_S = 4.33 ohms (E)
4.62 amps (Read F)

4.62 – 2.1 = 2.52 amps
12 volts (G)
2.52 amps (H)
$P_{Z\,MAX}$ = 30 watts (Read I)

$T_{A\,MAX}$ = 50°C (J)
30 watts (K)
θ = 4.15 °C/watt (Read N)

θ_Z = 1.0°C/watt
θ_1 = 0.8°C/watt
θ_S = 4.15 – 1.8 = 2.35 °C/watt (N)
A_{HS} = 260 sq. in. (Read M)

V_Z = 12 volts (O)
ΔT = 30°C (P)
219 mV (Read Q)

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Sample Problem – A regulated supply for a constant output current of 2.1 amperes is required. The primary power supply varies between 22 and 32 volts. The maximum design ambient is 50°C. An ambient temperature swing of 30° is anticipated. A teflon insulator with grease is used. $\theta_i = 0.8$°C/watt. Values – $V_{1\,MIN} = 22$ volts, $V_{1\,MAX} = 32$ volts, $I_L = 14\ (.150) = 2.1$ amperes. $V_Z = 12$ volts nominal zener rating. (see calculations on other side).

The (L) Scale – The thermal computation for heat sink area (Step 4) can be used for any other semi-conductor device for which the maximum allowable junction temperature, and the thermal resistance are known. For example, some Motorola Power Transistors have a $T_{CJ\,MAX}$ of 90°C and a θ_T of 1°C/Watt. For such a computation, subtract the ambient from the rated junction maximum temperature and enter their difference on Scale L. The balance of the calculation is as outlined in Step 4.