Pseudo zener

If you ever had to buy a 5 W zener you'll have found that they cost the earth. This 'active zener' circuit uses three components but costs a whole lot less than a power zener up to many watts rating.

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THE CIRCUIT CONSISTS of a transistor Q1 which dissipates most of the power and a zener diode ZD1 which supplies a reference voltage. When the voltage on the collector is greater than the total voltage across the zener and the transistor's base-emitter, Q1 will start to conduct, lowering the voltage on the collector. The circuit will reach a point of equilibrium where only enough current flows into the base of Q1 via ZD1 to maintain the collector-emitter voltage.

A zener diode is usually operated reverse biased i.e: positive is applied to the cathode. However, when it is forward biased it will conduct with only less than one volt (approximately 0.65 V depending on the current) across it. To simulate this in the artificial zener a diode D1 can be used although in most applications this is not necessary.

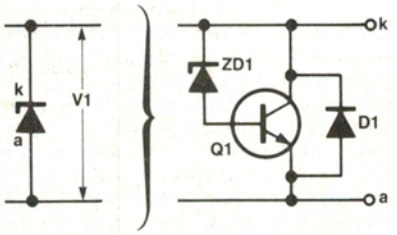
Transistor Q1 still has to dissipate the power that would otherwise be dissipated in an expensive zener. There is no way of avoiding this dissipation and it should be remembered when heatsinking Q1.

Table 1 enables you to select the transistor type depending on the zener diode that you require. Information is given as to whether or not the transistor needs to be heatsinked. If Q1 does require heatsinking the maximum temperature of the mounting base is given; if Q1 does not need to be heatsinked then the maximum ambient operating temperature is stated.

As an example, a pseudo zener of 33 V at 400 mA is required (33 V is part of the standard zener ranges). If you look down the 40 V column (the lowest voltage in the table above the voltage required) and across the 500 mA row (the lowest current above the 400 mA required) you will find that you need a 2N3055 transistor heatsinked and with a mounting base temperature that is less than 170°C. The zener diode that is used as a reference needs to have a voltage rating of 32.35 V.

ZD1 = V1 − 0.65 from table
∴ ZD1 = 33 − 0.65
∴ ZD1 = 32.35 V

The nearest zener diode easily available has a voltage rating of 33 V which gives a nominal V1 of 33.65 V and a maximum of 33.8 V.



V1 (max.) = ZD1 + 0.8 V from table
∴ V1 (max.) = 33 V + 0.8 V

This excludes the tolerance of the zener diode and assumes the transistor is at 25°C. The temperature coefficient of the transistor is approximately −2 mV/°C.

The 33.8 V maximum voltage is a pessimistic rating and should be less; 0.8 V in 33 V is only one part in 42 anyway.

	8 V	16 V	40 V	
Transistor **Heatsink** **Max. temp.**	BD137 no 50°C ZD1 = V1 − 0.65 V1 < ZD1 + 0.80	BD137 no 50°C ZD1 = V1 − 0.65 V1 = ZD1 + 0.80	BD137 no 50°C ZD1 = V1 − 0.65 V1 = ZD1 + 0.80	**25 mA**
Transistor **Heatsink** **Max. temp.**	BD137 no 50°C ZD1 = V1 − 0.67 V1 < ZD1 + 0.84	BD137 no 50°C ZD1 = V1 − 0.67 V1 < ZD1 + 0.84	BD137 yes 110°C ZD1 = V1 − 0.67 V1 < ZD1 + 0.84	**50 mA**
Transistor **Heatsink** **Max. temp.**	BD137 no 50°C ZD1 = V1 − 0.77 V1 < ZD1 + 0.88	BD137 yes 110°C ZD1 = V1 − 0.77 V1 < ZD1 + 0.88	BD137 yes 110°C ZD1 = V1 − 0.77 V1 < ZD1 + 0.88	**100 mA**
Transistor **Heatsink** **Max. temp.**	BD137 yes 110°C ZD1 = V1 − 0.73 V1 < ZD1 + 0.90	BD137 yes 110°C ZD1 = V1 − 0.73 V1 < ZD1 + 0.90	2N3055 yes 188°C ZD1 = V1 − 0.65 V1 < ZD1 + 0.68 1 watt zener	**200 mA**
Transistor **Heatsink** **Max. temp.**	BD137 yes 110°C ZD1 = V1 − 0.81 V1 < ZD1 + 1.00	2N3055 yes 188°C ZD1 = V1 − 0.65 V1 < ZD1 + 0.80	2N3055 yes 170°C ZD1 = V1 − 0.65 V1 < ZD1 + 0.80 1 watt zener	**500 mA**
Transistor **Heatsink** **Max. temp.**	2N3055 yes 188°C ZD1 = V1 − 0.70 V1 < ZD1 + 1.00 1 watt zener	2N3055 yes 170°C ZD1 = V1 − 0.70 V1 < ZD1 + 1.00 1 watt zener		**1 A**
Transistor **Heatsink** **Max. temp.**	2N3055 yes 170°C ZD1 = V1 − 0.80 V1 < ZD1 + 1.30 1 watt zener			**2 A**

Table 1. Pseudo-zener cross-referenced with the required transistor. Unless stated the zeners are rated at 400 mW.