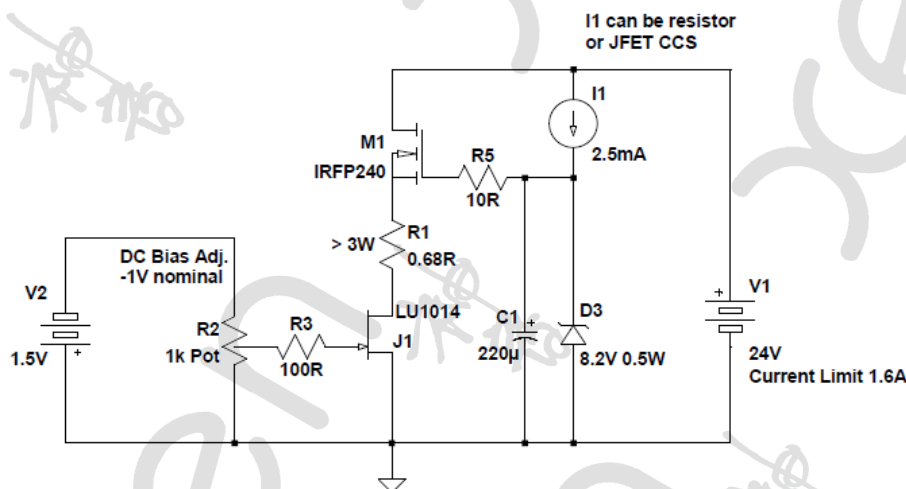


LU1014 Circlotron Power Buffer Bias Compensation

XEN Audio
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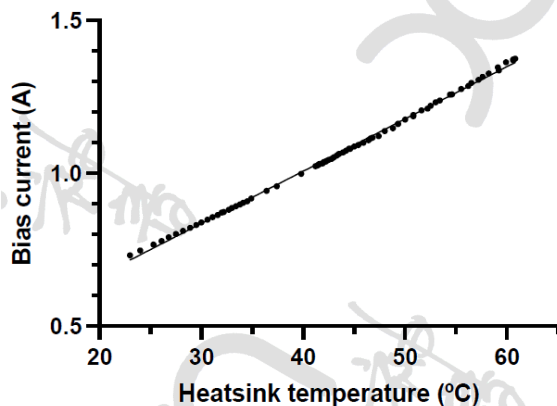
LU1014 Temperature Coefficient

Without the source resistor, and with the high Y_{fs} of the LU1014, any positive tempco of the power JFET can turn into a large increase in bias current. We quickly set up a test on a single triode cell on a heatsink, and measure the change in current with heatsink temperature. The following is a schematic of such a test setup. The FETs must be placed onto a suitable heatsink, without saying. The gate voltage of the LU1014 is to be continuously adjusted to keep the bias current constant with increasing temperature.



For the particular batch of devices we measured, this turned out to be a perfect straight line with a slope of $-3\text{mV}/^\circ\text{C}$. If uncompensated (i.e. V_{gs} kept constant), the bias current will rise at $17\text{mA}/^\circ\text{C}$, or 0.51A increase in bias for 55°C heatsink temperature.

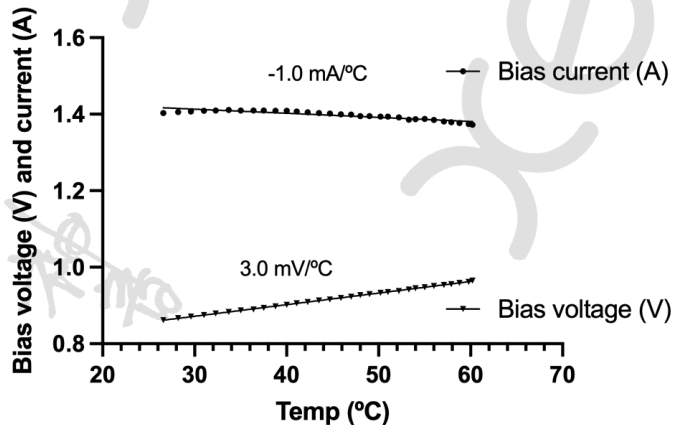
Current vs. Temp



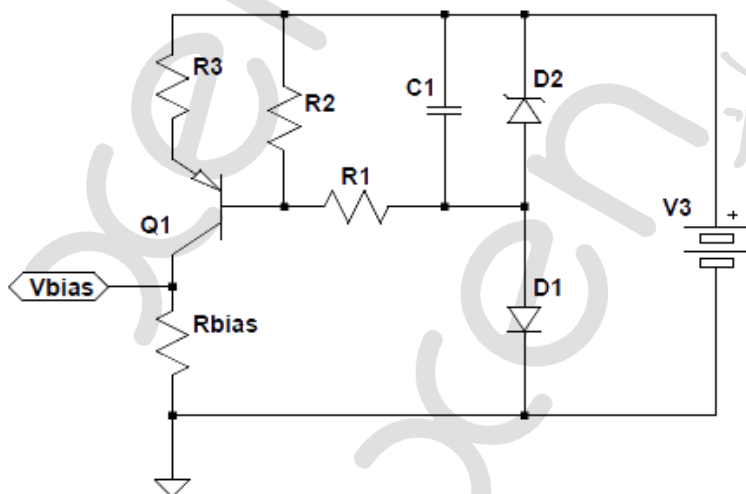
The immediate thought was to use a third LU1014 as compensating element, wire that as a current source, and pass the current through a resistor to generate a bias voltage with positive tempco. But this turns out to be way too large, way over $10\text{mV}/^\circ\text{C}$, resulting in a large drop in bias with increasing

temperature, which we also do not want. We want to aim at just over $3\text{mV}/^\circ\text{C}$, so that bias is nearly constant but slightly reducing with temperature, to be on the safe side. So we set the target value at $3.2\text{mV}/^\circ\text{C}$.

The V_{be} of a standard bipolar transistor is known to have a defined tempco of $-2\text{mV}/^\circ\text{C}$. We can make use of that in a simple circuit to generate both the bias voltage and the tempco we want. This has subsequently been tested, and the results are very encouraging. Bias is now stable to $-1\text{mA}/^\circ\text{C}$, or just -30mA with 30°C rise in heatsink temperature. And it is slightly decreasing, just as we wanted.



Id vs Temp with bias compensation



Schematics Vbias circuit

Since the values of your specific devices might be different, it is important to understand how the circuit works, and how to dimension the components. In the schematics above, D2 is a temperature compensated 2.5V voltage reference. D1 is a 3mA constant current source, such as a single 2SK209GR JFET to bias D2. R1 / R2 forms a potential divider to set the voltage at the base of Q1. This base voltage is constant against temperature. With a tempco of the V_{be} of Q1 of say $-2\text{mV}/^\circ\text{C}$, R3 will have an effective positive tempco of $+2\text{mV}/^\circ\text{C}$. With the ratio of R3 : Rbias, the desired bias voltage can be set, with the required temperature coefficient.

We have chosen a Toshiba TO126 BJT on purpose for good thermal coupling to a heatsink. This should be please close to the midpoint between the 2 LU1014's if one Circlotron is used.

Dimensioning of the bias compensation circuit

Assuming :

desired V_{gs} at 22°C of the LU1014 = -0.87V

desired V_{bias} tempco = $+3.2\text{mV}/^{\circ}\text{C}$

tempco of V_{be} = $-2\text{mV}/^{\circ}\text{C}$

V_{be} of BJT in circuit ($\sim 3\text{mA } I_c$) = 0.6V

Voltage across R_3 = $0.87/(3.2/2) = 0.54\text{V}$

Voltage at PNP base (rel. to battery + ve) = $0.54 + 0.6 = 1.14\text{V}$.

Potential divider $R_1:R_2 = 1.2\text{k}:1\text{k}$, such that voltage across $R_2 = 1.14\text{V}$

$R_{bias} = 330\Omega$ for 2.6mA bias at 0.87V (for LU1014 at 1.2A)

$R_3 = 200\Omega // 2.7\text{k}$ to get 0.54V as required.