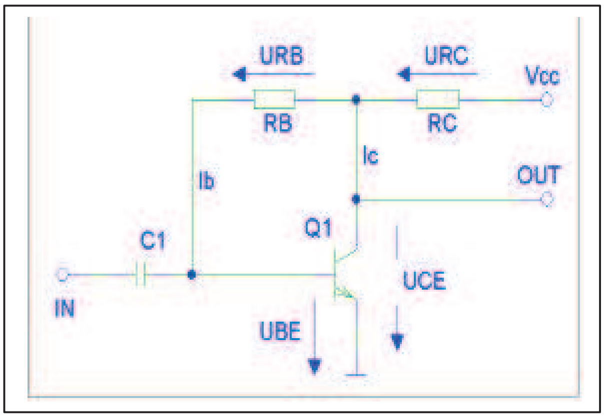
1.3.2 DC bias point adjustment at Transistors

As a contrast to the easy bias setup at MMICs, there is shown the design of a setup used at eg. audio or IF amplifiers.



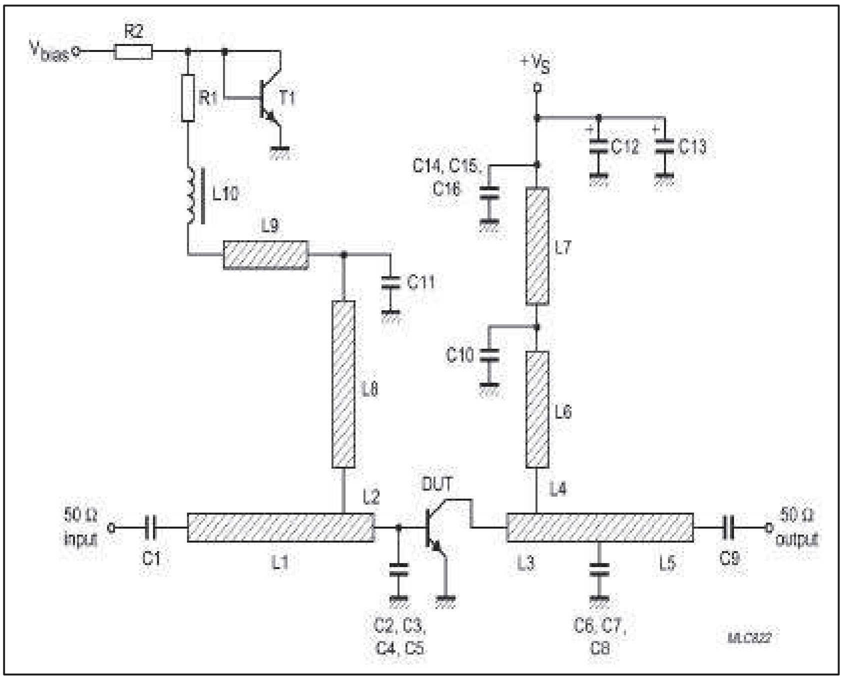
DC bias setup with stabilization via Voltage feedback

$$h_{FE} = \beta = B = \frac{I_C}{I_b} \qquad R_C = \frac{V_{CC} - U_{CE}}{I_b + I_C} = \frac{V_{CC} - U_{CE}}{I_C\left(\frac{h_{FE}+1}{h_{FE}}\right)}$$

$$R_C = \frac{V_{CC} - U_{CE}}{I_C\left(h_{FE}+1\right)} \cdot h_{FE}; \; V_{CC} - I_C \cdot R_C = V_{CE} = I_b \cdot R_B + U_{BE}$$

$$R_B = h_{FE} \cdot \left(\frac{V_{CC} - U_{BE}}{I_C} - R_C\right) = h_{FE} \cdot \frac{V_{CE} - V_{BE}}{I_C}$$

The advantage is a very high resistive resistor R_B. It's lowering of the input impedance at terminal [IN] can be negated. Due to it a possible picked up IF-Band filter is less loaded. Due to missing of the emitter feedback resistor high gain is achieve from Q1. This is need for narrow bandwidth high gain IF amplifiers. The disadvantage is a very low stability of the operating point caused by the Si BE-Diodes' relative linear negative temperature coefficient of ca.$V_{BE} \approx$-2.5mV/K into amplified $I_C = \frac{V_C - V_{BE}}{R_B} \cdot h_{FE}$ This can be lowered by adding an additionally resistor between ground and the emitter.



An emitter resistor has the disadvantage of gain loss or the need of a bypassing capacitor. Additionally the transistor is loosing quality of gnd performances (instability) and an emitter heat sinking into the gnd plane. At medium output power, the bias setup must be stabilized due to the increased junction temperature causing dc drifting. Without stabilization the transistor will burn out or distortion can rise up. A possible solution is illustrated in the adjacent picture (***BFG10***). Comparable to the BGA2003, a current mirror is designed together with the dc transistor T1. T1 works like a diode with a V_{CE} (V_{BE}) drift close to the RF transistor (DUT) in the case of close thermal coupling. With β_1=β_{DUT} and $V_{BE-1} \approx V_{BE-DUT}$ we can do a very simplified algebraic analysis:

$$V_T \cdot \ell n\left(\frac{I_{C-1}}{I_{CO}}\right) \approx V_T \cdot \ell n\left(\frac{I_{C-DUT}}{I_{CO}}\right)$$

finalizing into a very temperature independent relation ship of $I_{C-DUT} \approx I_{C1} \approx (V_{bias}-V_{BE})/R_2$
For best current imaging the BE die structure areas should have similar dimensions.