The first equation sets the collectors of the output transistors considerably higher than their bases. This is to ensure that the AC output signal oscillating on pins 6 and 12 does not drop the collector voltage below that of the base. The resulting operational mode change (from linear to saturation) could be undesired.

The second equation ensures that the emitter voltage of the carrier-input (top-level) transistors remains well above the base of the modulating signal input (mid-level) transistors. This keeps the mid-level transistors in linear operation.

The third equation keeps the voltage at the base of the mid-level transistors comfortably above the voltage at the collector of the current-source (bottom) transistors. This maintains these transistors in linear operation.

With this in mind, one can redefine the biasing equations to more accurately reflect what is physically occurring in the circuit.

\[
(V_6, V_{12}) - (V_8, V_{10}) \geq 2V \\
(V_8, V_{10}) - (V_1, V_4) \geq 2.7V \\
(V_1, V_4) - (V_5) \geq 2.7V
\]

These mathematical results were verified in simulation using National Instruments Multisim. However, before discussing these results, it is first useful to understand the other design choices involved in modulation.

The circuit included in the MC1496 datasheet.

This configuration eliminates the negative rail, but still recommends a 12V source. Operation on non-standard voltages requires understanding the transistor level operation of the MC1496.

The modulator is composed of three layers of BJT transistors. The voltage drop across a BJT is around 0.7V. As a consequence, it seems feasible that this circuit could be powered by a 3.2V source with headroom and legroom for an AC output.

The MC1496 datasheet lists the biasing conditions for the circuit as follows:

\[
(V_6, V_{12}) + AV_{in} > (V_8, V_{10}) \\
(V_8, V_{10}) - 0.7 > (V_1, V_4) \\
(V_1, V_4) + AV_{in} > 0.7V
\]

With these equations used as guidance, the use of a much lower voltage rail is evident. One must simply monitor the gain of the circuit to maintain correct biasing.

These mathematical results were verified in simulation using National Instruments Multisim. However, before discussing these results, it is first useful to understand the other design choices involved in modulation.