

CHAPTER SUMMARY

- Single-ended signals are voltages measured with respect to ground. A differential signal consists of two single-ended signals carried over two wires, with the two components beginning from the same dc (common-mode) level and changing by equal and opposite amounts.
- Compared with single-ended signals, differential signals are more immune to common-mode noise.
- A differential pair consists of two identical transistors, a tail current, and two identical loads.
- The transistor currents in a differential pair remain constant as the input CM level changes, i.e., the circuit “rejects” input CM changes.
- The transistor currents change in opposite directions if a differential input is applied, i.e., the circuit responds to differential inputs.
- For small, differential changes at the input, the tail node voltage of a differential pair remains constant and is thus considered a virtual ground node.
- Bipolar differential pairs exhibit a hyperbolic tangent input/output characteristic. The tail current can be mostly steered to one side with a differential input of about $4V_T$.
- For small-signal operation, the input differential swing of a bipolar differential pair must remain below roughly V_T . The pair can then be decomposed into two half circuits, each of which is simply a common-emitter stage.
- MOS differential pairs can steer the tail current with a differential input equal to $\sqrt{2I_{SS}/(\mu_n C_{ox} W/L)}$, which is $\sqrt{2}$ larger than the equilibrium overdrive of each transistor.
- Unlike their bipolar counterparts, MOS differential pairs can provide more or less linear characteristics depending on the choice of the device dimensions.
- The input transistors of a differential pair can be cascoded so as to achieve a higher voltage gain. Similarly, the loads can be cascoded to maximize the voltage gain.
- The differential output of a perfectly symmetric differential pair remains free from input CM changes. In the presence of asymmetries and a finite tail current source impedance, a fraction of the input CM change appears as a differential component at the output, corrupting the desired signal.
- The gain seen by the CM change normalized to the gain seen by the desired signal is called the common-mode rejection ration.
- It is possible to replace the loads of a differential pair with a current mirror so as to provide a single-ended output while maintaining the original gain. The circuit is called a differential pair with active load.