Comparing High Linearity Amplifier Topologies for RF Systems

High linearity is a critical requirement in RF front-end design, ensuring low distortion, high intercept points, and improved signal integrity. This note compares three common amplifier topologies — Darlington, Push-Pull, and Parallel — in terms of distortion characteristics, intercept point (IP2, IP3) performance, and other operational trade-offs. It also provides guidance for selecting the appropriate topology for different RF applications.

Distortion Characteristics

- **Darlington**: does not inherently cancel distortion; distortion products are directly influenced by transistor design and biasing
- **Push-Pull:** naturally cancels even-order harmonics due to balanced configuration, reducing total distortion
- **Parallel:** offers no intrinsic distortion cancellation; distortion depends on device matching and operating point
- **Key takeaway:** push-pull designs are advantageous when harmonic suppression is a priority

Intercept Point (IP) Performance

IP2 (Second Order Intercept)

- **Darlington:** fundamentally inferior to push-pull due to lack of distortion cancellation
- **Push-Pull:** excellent IP2 performance, making it ideal for demanding RF systems
- **Parallel:** does not inherently improve IP2

IP3 (Third Order Intercept)

- **Darlington:** can offer respectable IP3 with careful design
- **Push-Pull:** strong IP3 performance, benefiting from reduced distortion
- **Parallel:** IP3 performance is comparable to Push-Pull when properly implemented

Other Performance Metrics

- **Darlington:** lower output impedance and supply current improvements; generally lower efficiency
- **Push-Pull:** supports higher output power, better efficiency, and improved load handling
- **Parallel:** provides higher output power by combining devices but requires careful current sharing to maintain linearity

Application Guidance

- **When IP2 performance is critical:** select push-pull topology
- **For general gain block requirements where linearity is important:** Darlington can be a cost-effective option
- **When output power is the sole requirement:** parallel topology is best suited

Summary

- **Darlington:** simple implementation, moderate IP3 performance, but limited IP2
- **Push-Pull:** best for linearity and harmonic suppression, suitable for high-performance RF systems
- **Parallel:** best for output power scaling but requires careful design for thermal and current balance; the choice of topology should align with the primary performance requirement: linearity, gain, or output power

Figure 1: Harmonic Distortion - Darlington vs Push-Pull

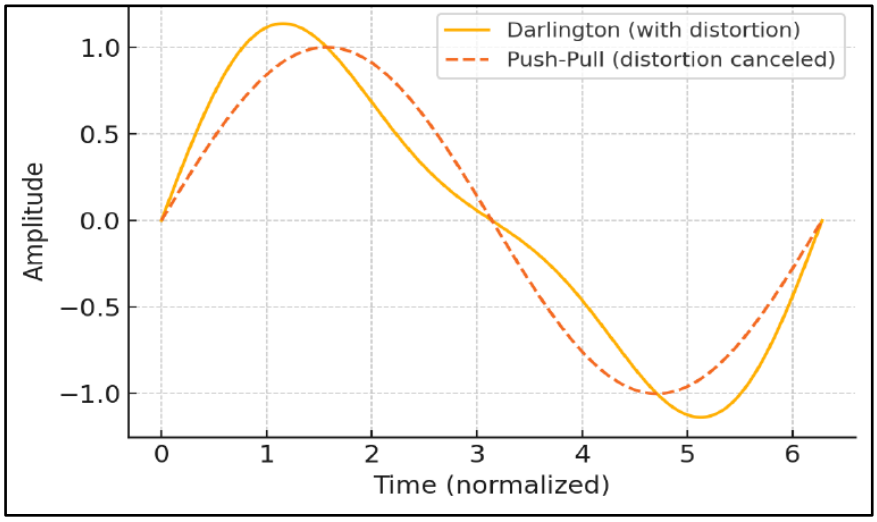

Figure 2: Relative IP3 Performance by Topology