Biasing Asymmetrical Doherty RF Power Transistor

RF Power Factsheet

1. Biasing Asymmetrical Doherty RF Power Transistor

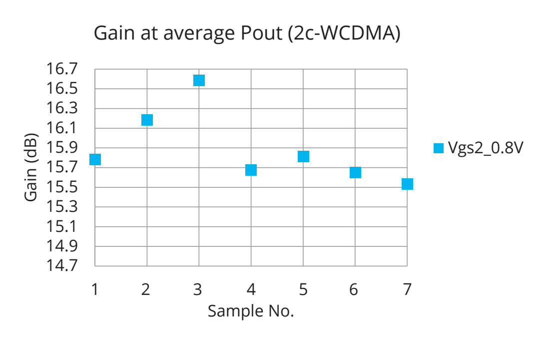
The ever-increasing need for higher efficiency in base station power amplifiers calls on new variants of the Doherty topology. Optimised main and peak amplifiers result in asymmetrical Doherty designs that use different transistors for each path. Until recently, symmetrical push-pull devices have been used in single device Doherty amplifiers. Ampleon's range of LDMOS transistors, however includes dedicated asymmetrical designs that are optimised for efficiency in today's demanding cellular base station market. In order to enjoy the benefits of low spread in RF performance, care must be taken in biasing these devices appropriately. This Factsheet highlights the key aspects of biasing these asymmetrical Doherty devices.

1.1 General Biasing Method of Doherty Amplifiers

In general, the main amplifier of a Doherty device is biased in class-AB at a fixed Id and the peak amplifier is biased in class-C at a fixed Vgs voltage. Owing to spread in semiconductor processing, the Vt (threshold voltage) of LDMOS dies vary. This means that if a transistor is biased at a fixed Vgs, its Id can vary depending on its actual Vt. The RF performance of a transistor, like gain and efficiency, correlates strongly with the Id and hence, when the Id varies due to spread of Vt, the RF performance also spreads accordingly.

The main amplifier is biased in class-AB at fixed Id. Any spread in Vt of the LDMOS dies' main amplifier can be compensated by measuring the actual Id for each device and then adjusting the Vgs, such that the Id is maintained. The peak amplifier is biased in class-C where no Id flows until it is driven by a relatively high RF signal level. Therefore, the compensation method as described for the main amplifier, cannot be directly applied to the peak amplifier.

If the peak amplifier is not compensated for its Vt spread, the RF performance of the Doherty amplifier would show a significantly higher spread. The graphs below show the spread of gain and efficiency of BLF8G20LS-260A device in its Doherty test circuit at average output power of 50 W at 28 V, where the main amplifier is biased at fixed Id of 750 mA and the peak amplifier is biased at a fixed Vgs of 0.8 V. Two of the seven transistors (No. 2 and No.3) chosen for this test have significantly different Vt values of the LDMOS dies used in peak amplifier compared to the rest.



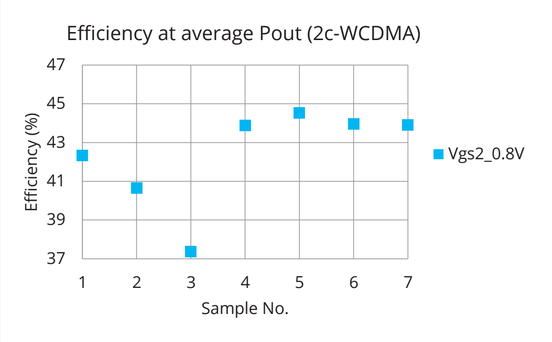
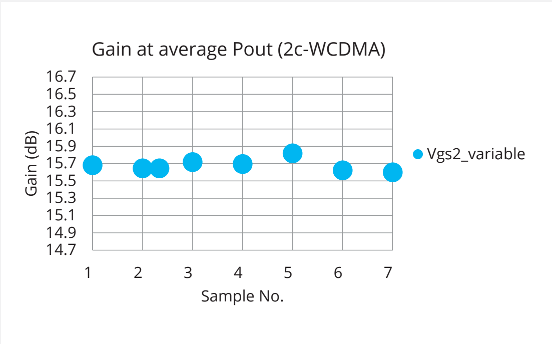


Fig. 1. Power gain and drain efficiency with 2c-WCDMA (5 MHz spacing) at center frequency of 1810 MHz. V_{DS} = 28 V, $I_{Dq\,(main)}$ = 750 mA, $V_{GS(amp)peak}$ = 0.8 V

1.2 Recommended Biasing Method of Doherty Amplifiers

The spread in RF performance shown in the graphs on the previous page could be reduced by compensating for the spread in Vt of peak devices. Instead of biasing the peak amplifier with fixed Vgs value, the idea is to follow a two step process. First step is to bias the peak device to a predefined class-AB Id value. In this way, the Vgs needed is determined and then in the second step the class-C Vgs bias value is found by taking a fixed offset from the Vgs value found in first step. This method ensures that the Vgs bias voltage for the LDMOS dies in the peak amplifier tracks its Vt shift for each transistor and hence helps to significantly reduce the spread in RF performance. The graphs below show the spread of RF performance using this concept.



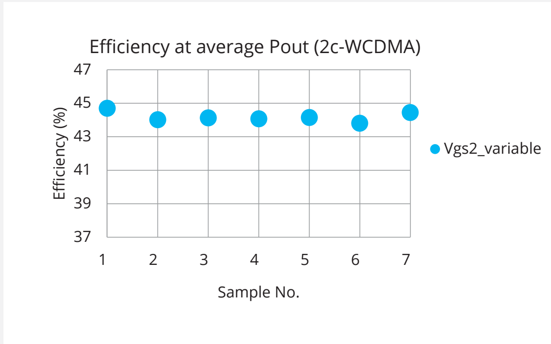


Fig. 2. Power gain and drain efficiency with 2c-WCDMA (5 MHz spacing) at center frequency of 1810 MHz.
V_{DS} = 28 V, $I_{Dq (main)}$ = 750 mA, $V_{GS(amp)peak}$ = varied based on Vt.

1.3 Biasing Information in Datasheet

The Ampleon datasheets of asymmetrical Doherty devices currently mention only the typical Vgs value for the peak amplifier. The limits of RF parameters like gain, efficiency, RL and ACPR with 1c-WCDMA or 2c-WCDMA published in Ampleon datasheets of asymmetrical Doherty devices are derived based on RF measurements in Doherty test circuit using the above mentioned biasing technique.

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