MicroNote #709

Playing the 3G Power Game

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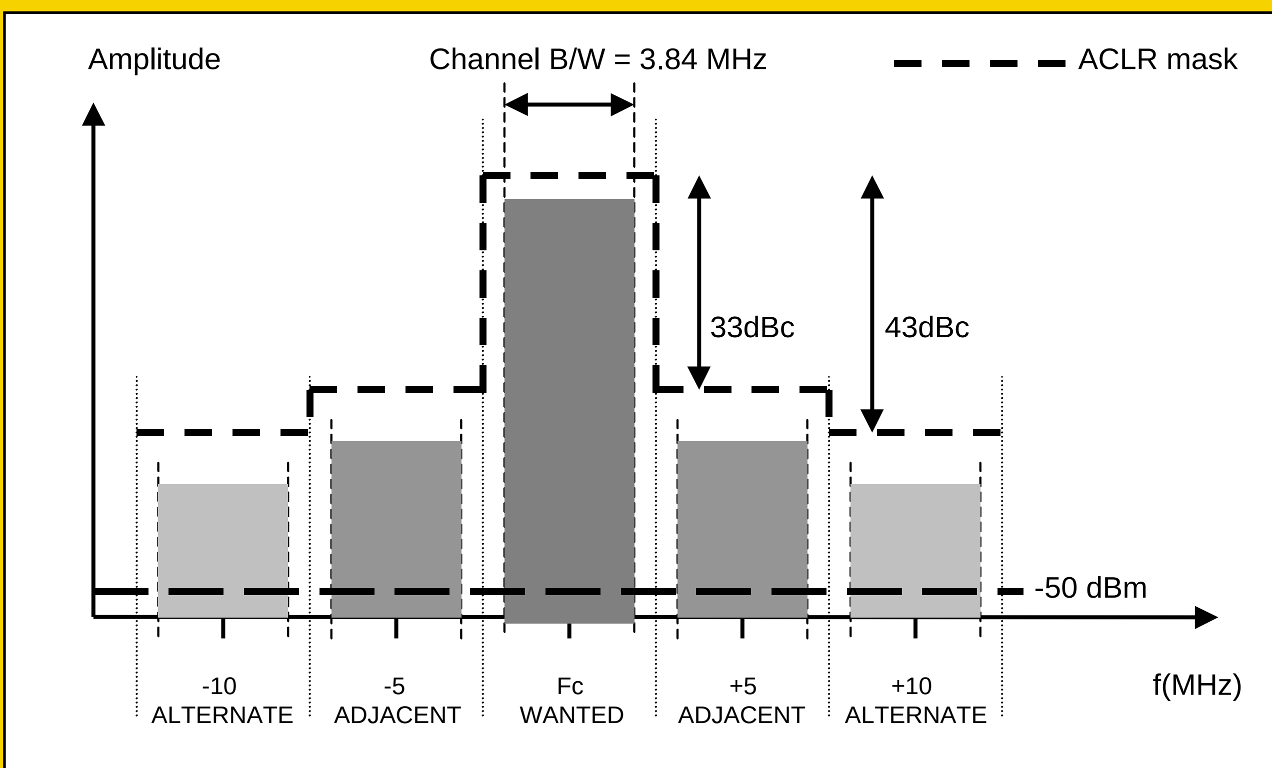
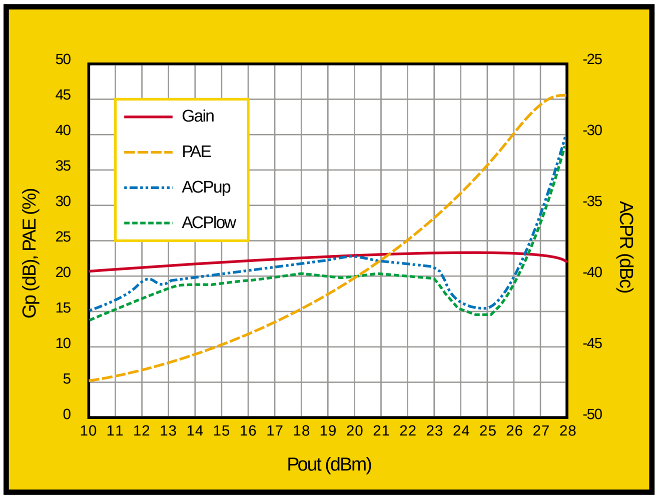
The concept of mobile connectivity is changing with deployment of GPRS services and is likely to change further with the advent of 3G services. The consumer, who has become accustomed to small and compact phones with standby times of days and talk times of several hours, will now demand similar performance from the 3G phones but with added technology differentiators of always-on connections, interactive and fast moving games and m-commerce as well as additional hardware like MP3 players, video camera and color displays. This will require greater processing power from the base-band processor. Processing power is measured in MIPS, Mega Instructions Per Second. Current GSM phones require about 10 MIPS; GPRS/HSCSD about 100 MIPS; 1000 MIPS for EDGE and potentially 10,000 MIPS for UMTS/WCDMA. This translates to higher drain current from the battery. The challenge for phone designers then is to minimize the battery consumption where ever he/she can.

UMTS/WCDMA is one of the leading air interface solutions and employs spectrally efficient, non-constant envelope digital modulation schemes; therefore, a linear power amplifier is needed to avoid signal clipping from

ACLR Requirements



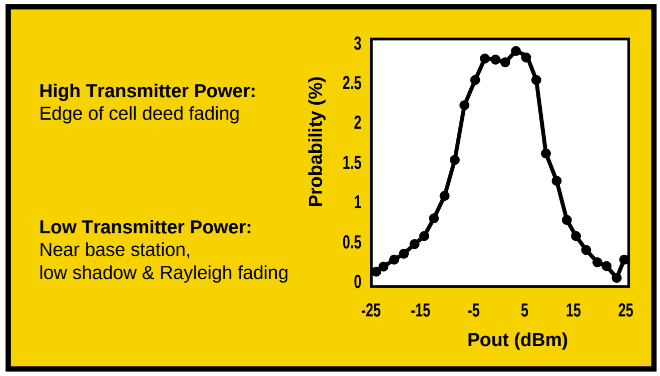
peak envelope excursions and limit the resultant spectral re-growth. The 3GPP specification TS 25.101 has placed a stringent regulatory requirement on ACLR (Adjacent Channel Leakage power ratio).



The Case for Low Idle Current

The characterisation of handset transmitters is usually dominated by the power devices used. Selecting an appropriate device is critical for optimum operation. Microsemi's MWS11PH41, an InGaP HBT-based power amplifier, is a leading candidate for WCDMA handset transmitter applications due to its high PAE (>40%) coupled with a very low quiescent or idle current (<40mA).

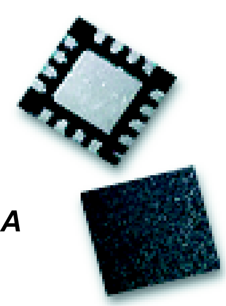
The WCDMA characteristics of the InGaP HBT were evaluated with a 3GPP complaint QPSK modulated uplink signal with a chip rate of 3.84 Mega chips per second at 1.95 GHz under various Iq (Idle current) conditions. The optimum source and load impedances were determined through source/load-pull measurements to obtain a maximum PAE(>40%) while maintaining an ACPR1 of less than -38dBc and an output power of 27dBm. An ACPR1 dip occurs in the region between 24dBm and 27dBm resulting in additional improvement in PAE for maximum allowed ACPR specs. The first adjacent channel distortion (ACPR1) result from both the 3rd order and the 5th order distortion mechanisms, whereas the second adjacent channel is dominated by the 5th order distortion mechanisms. The overall distortion at IM3 frequency (ACPR1) is a vector sum of the distortions generated by the third and fifth order non-linearity. When the two distortions have a comparable magnitude and a near 180 degrees phase difference, cancellation between these distortions would occur, resulting in a dip phenomenon.



The idle current generally defines efficiency at low powers. In CDMA systems the output power of mobile terminals is controlled so that the effective received signal to noise at base station receiver from each of the mobile terminals is the same. This is done in order to offset the effects of distance and fading and to optimize cell capacity. Probability distribution characteristics of phone's output power show that the average output power from a typical mobile terminal is approximately +10dBm under suburban conditions, and +5dBm under urban conditions.

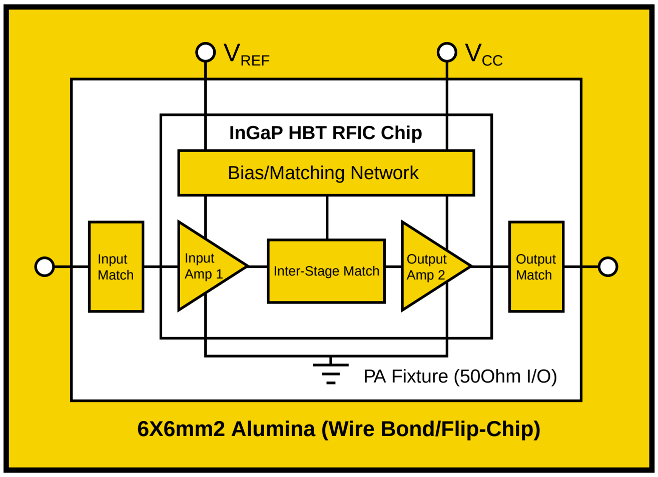
This means that transmission at maximum output power is statistically low and the power amplifier operates largely in "backed off" mode the majority of the time. It therefore makes sense to optimize the PA to a statistically high 'long term' output power level.

WCDMA PA Performance (Lead Chip)



Key Features

- ***Vcc = 3.5V***
- ***Quiescent Current: Icq = 37mA***
- ***Pout = >27dBm***
- ***Power Gain = 23.5dB***
- ***PAE = 41.1% @ Pout=27.2dBm***
- ***ACPR = -38dBc @ Pout=27.2dBm***



6X6mm2 Alumina (Wire Bond/Flip-Chip)

The Case for Variable Bias Control
One way of optimizing the PA performance is to couple the power control processes with base or collector bias control. Reducing the base bias voltage with reducing output power results in improved efficiency since the conduction angle is reduced. Reducing the collector bias voltage with reducing output power results in more of the active device's load line traversing the load and hence improving the power transfer efficiency to the load. The collector voltage control approach gives improved performance over base bias control strategy because the amplifier is operating close to gain compression. A buck dc-dc converter can provide the variable collector bias. Sufficient switching speed (>1MHz) is used to minimize the external inductor and filter capacitor size and maintain good converter efficiency (>90%). The use of a variable bias can provide significant amplifier efficiency in the low output power regime as shown and lead to similar reduction in battery talk time and/or size. This advantage will be dictated by the cost of the buck converter and associated components, its size and the relative power consumption of the PA respect to the total phone, particularly the baseband. Although the first-generation 3G baseband chips are power hungry, technology advances should reduce their relative power consumption to PA levels making the dc-converter variable bias control a significant overall benefit.

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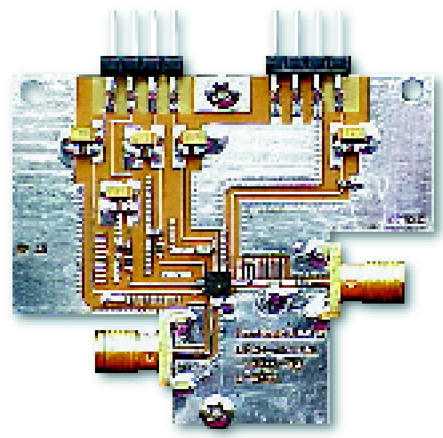
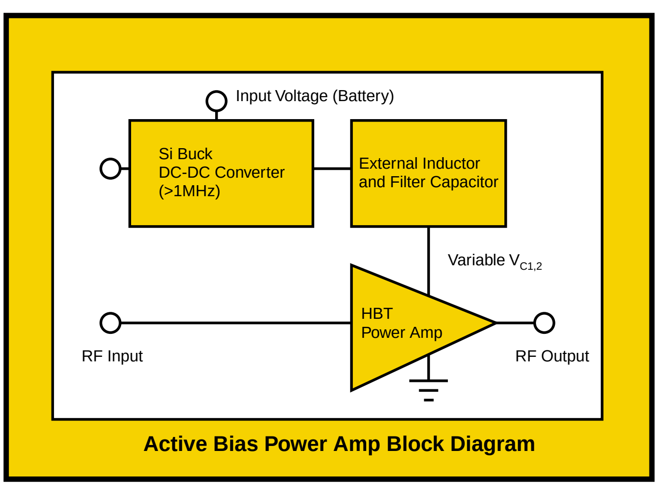


Active Bias Power Management of InGaP HBT Power Amp
DC-DC Converter with 2-Bit (4) Bias Level (In Development)



Active Bias Power Amp Block Diagram