An Ultra High Ruggedness InGaP/GaAs HBT for Multi-Mode / Multi-Band Power Amplifier Application

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Abstract

InGaP/GaAs HBT technology has been widely used in power amplifier (PA) design for wireless communications due to its high linearity and high efficiency. In recent years Multi-Mode / Multi-Band (MMMB) power amplifier architecture has emerged as the dominant trend with the strong growth of the smart phone. Integrated 4G MMMB solutions need to support GSM, UMTS and LTE schemes. One of the requirements for the GSM PA is HBT ruggedness, with the ability to maintain peak performance under the stress of high voltage standing wave ratio (VSWR) mismatch. We present an ultra high ruggedness HBT technology (Fig. 1) that can sustain a VSWR mismatch of 50:1 without trading off RF performance. We introduce both horizontal and vertical emitter finger orientations for added flexibility of device layout (Table 1 and Fig. 2). In addition to our conventional Type A HBT we also introduce an improved transistor layout with higher maximum available gain (Table 2 and Fig 3).

This work demonstrates an ultra high ruggedness HBT which survives VSWR 50:1 ruggedness testing at VCE = 5V without performance degradation (Table 4). If VSWR is kept at 10:1 and sweeping VCE operation voltage, this technology survives VCE = 7V. Compared to the reference sample this work shows a 2 volt VCE improvement, in line with the requirements for GSM application (Table 5). Furthermore, we present our new Type-B HBTs with higher gain performance and a layout solution which makes it easier for the designer to realize a MMMB PA in a single InGaP/GaAs HBT chip.

Fig. 1 The Cross section photos of HBT unit cell.

Table 1 The illustration of horizontal and vertical orientation HBTs

Horizontal orientation HBTs	Vertical orientation HBTs
Collector Emitter Base Emitter Collector	Collector Base Emitter Emitter Collector

Table 2The illustration of Type-A and Type-B HBTs

Type-A HBTs	Type-B HBTs
Collector Emitter Base Emitter Collector	Collector Emitter Base Emitter Collector

Fig. 2 The comparison results of Maximum Available Gain (MAG) between Type-A and Type-B HBTs. Type-B HBTs show higher MAG than Type-A HBTs for handset application.

Fig. 3 The illustration of both horizontal and vertical orientation HBTs applying to Multi-Band PA.

Table 3 Key device DC and RF characteristics

Parameters	Unit	Typical Value
Current Gain @ 1.25kA/cm^2		75
Turn-on voltage @ 1.25kA/cm^2	V	1.265
BVceo @ 0.05kA/cm^2	V	18.5
BVcbo @ 0.05kA/cm^2	V	37
BVebo @ 0.05kA/cm^2	V	7.0
Ft @ 25kA/cm^2	GHz	28

Table 4

Various VSWR from 10:1 to 50:1 ruggedness test results under 35dBm output power for VCE was 3.6V and 5V. Power cell size is 11520um^2.

VSWR	10:1	20:1	30:1	40:1	50:1
VCE=3.6V	Passed	Passed	Passed	Passed	Passed
VCE=5V	Passed	Passed	Passed	Passed	Passed

Table 5 Ruggedness test results under VSWR 10:1 for Device-A and Device-B. Device size is 3um*40um*3fingers.

VCE	3.6V	5V	6V	6.5V	7V	7.5V
Device A	Passed	Passed	Failed			
Device B	Passed	Passed	Passed	Passed	Passed	Failed