DESIGN OF WIDEBAND POWER AMPLIFIER WITH LOW INTERMODULATION DISTORTION

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UNIVERSITI TEKNIKAL MALAYASIA MELAKA

DESIGN OF WIDEBAND POWER AMPLIFIER WITH LOW INTERMODULATION DISTORTION

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Dedicated to my dearest dad and mum who supported me all the time and my friends who always by my side.

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ABSTRACT

A rising of the new technology developed globally has been happening along the recent years. However, the wide range power amplifier (PA) has been designed to cover more application in the operating range of frequency of the design amplifier. Until now, the wideband PA design still maintain as an arduous part in the microwave communication system. Additionally, a conventional single stage wideband PA has been suffering for its high intermodulation distortion which able to affect the performance of the design amplifier and harder to achieve the desired specification of the wideband PA. Compared to the design of the narrow band amplifier, wide band amplifier design provides more challenging to the pass band frequency of the amplifier. The main purpose of this project is to design a wideband PA with low intermodulation distortion which combine with the parallel coupled band pass filter to allow the frequency range from 2GHz to 3GHz (S-band) pass through the PA. This amplifier is designed double stage for the microwave application which included weather radar, satellite communication (space to earth), Wireless Networking (WLAN, WiMAX, cellular network, Bluetooth), mobile TV and satellite radio. The design concept has been used the multiple stage design structure which the multiple amplifier arranged in the parallel line and two power divider (coupler) are used to combine the several stages of the amplifier at the input and output port. A voltage divider Class-A amplifier is used to design the biasing circuit of the wideband PA which the transistor used is Avago Technologies's ATF-511P8 Gallium Arsenide (GaAs) high linearity E-pHEMT. Intermodulation Distortion (IMD3) product is used to determine the linearity of the design power amplifier. The lower the IMD3, the higher the linearity of the design amplifier. Regarding to the simulation result of design double stage PA, the IMD3 shows 65.187dBc which has lower than -33.622dBc for the single stage PA. Input and

output return losses, S11 and S22 show below -10dB along the operating frequency range, whereas the gain, S21 only can achieve above 5dB which lower than the aspect result (< 10dB). The power added efficiency (PAE) able to achieve more than 30% when the output power is more than 30dBm were at the 1dB gain compression point. The input third order intercept point (IIP3) is 37.5dBm while the output third order intercept point (OIP3) is 42.0dBm.

ABSTRAK

Peningkatan teknologi baru yang dibangunkan secara global telah berlaku di sepanjang tahun-tahun kebelakangan. Walau bagaimanapun, dalam pelbagai penguat kuasa (PA) telah direkabentuk untuk menampung lebih banyak aplikasi dalam pelbagai operasi frekuensi penguat reka bentuk. Sehingga kini, reka bentuk penguat kuasa jalur lebar masih lagi dikekalkan sebagai satu bahagian yang sukar dalam sistem komunikasi gelombang mikro. Di samping itu, konvensional penguat kuasa jalur lebar yang satu peringkat telah menderita bagi gangguan intermodulation yang tinggi yang mampu memberi kesan kepada prestasi sesuatu penguat reka bentuk dan sukar untuk mencapai spesifikasi dikehendaki penguat kuasa jalur lebar. Berbanding dengan rekabentuk penguat jalur sempit, jalur lebar bersepadureka bentuk menyediakan lebih mencabar untuk Pas band frekuensi penguat. Tujuan utama projek ini adalah untuk mereka bentuk sebuah penguat kuasa jalur lebar kuasa dengan herot-benyot intermodulation rendah yang menggabungkan dengan turas laluan selari serta band membolehkan julat frekuensi dari 2GHz 3GHz (S-kugiran) melalui di penguar kuasa. Penguat ini direka dua peringkat permohonan gelombang mikro radar cuaca, satelit komunikasi (ruangan ke bumi), rangkaian tanpa wayar (WLAN, WiMAX, rangkaian selular, Bluetooth), radio TV dan satelit mudah alih. Konsep reka bentuk telah digunakan reka bentuk pelbagai peringkat struktur yang penguat berbilang yang disusun dalam baris yang selari dan pembahagi kuasa dua (coupler) digunakan untuk menggabungkan beberapa peringkat penguat di pelabuhan pemasukan and keluaran. Penguat kelas A pembahagi voltan yang digunakan untuk mereka bentuk litar biasing daripada penguat kuasa jalur lebar yang transistor digunakan Avago Technologies ATF - 511P 8 Gallium Arsenide (suatu perigi GaAs) tinggi linearity E-pHEMT. Intermodulation produk herotan (IMD3) digunakan untuk menentukan kelinearan penguat kuasa reka bentuk. Yang mana lebih rendah IMD3 itu,

semakin tinggi kelinearan penguat reka bentuk. Berkenaan dengan hasil simulasi reka bentuk double peringkat penguat kuasa, menunjukkan IMD3 65.187dBc yang lebih rendah berbanding - 33.622dBc untuk peringkat tunggal PA. Kembali kerugian pemasukan and keluaran, S11 dan S22 tayangkan di bawah - 10dB sepanjang julat frekuensi operasi, manakala keuntungan, S21 hanya boleh mencapai di atas 5dB yang lebih rendah daripada hasil aspek (< 10dB). Kuasa menambah kecekapan (PAE) mampu mencapai lebih daripada 30% apabila kuasa output lebih daripada 30dBm berada di titik 1dB keuntungan mampatan. Titik memintas ketiga (IIP3) bagi pemasukan ialah 37.5dBm manakala Titik memintas ketiga bagi keluaran (OIP3) ialah 42.0dBm.

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LIST OF ABBREVIATIONS

RF	-	Radio Frequency
FYP	-	Final Year Project
UTeM	-	Universiti Teknikal Malaysia Melaka
FKEKK	-	Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
PA	-	Power Amplifier
WLAN	-	Wireless Local Area Network
WiMAX	-	Worldwide Interoperability for Microwave Access
GaAs	-	Gallium Arsenide
IMD	-	Intermodulation Distortion
IIP3	-	Input Third-Order Intercept Point
OIP3	-	Output Third-Order Intercept Point
PAE	-	Power Added Efficiency
PCS	-	Personal Communications Service
WCDMA	-	Wideband Code Division Multiple Access
RLL	-	Radio Local Loop
WLL	-	Wireless Local Loop

MMDS	-	Multichannel Multipoint Distribution Service
LTE	-	Long Term Evolution
GPS	-	Global Positioning System
ADS	-	Advanced Design System
DP	-	Distribution Pre-distortion
GaN	-	Gallium Nitride
CS	-	Common Source
CG	-	Common Gate
SOS	-	Silicon-On-Sapphire
CMOS	-	Complementary Metal–Oxide–Semiconductor
DE	-	Drain Efficiency
ET	-	Envelope Tracking
HSA	-	Hybrid Switching Amplifier
DC	-	Direct Current
VSWR	-	Voltage Standing Wave Ratio
GSM	-	Global System for Mobile Communication
LNA	-	Low Noise Amplifier
ACPR	-	Adjacent Channel Power Ratio
MAG	-	Maximum Available Gain
NF	-	Noise Figure