WiMAX Amplifiers And Their Application

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With the demand for wireless personal communications growing exponentially, complex modulation schemes have been deployed that offer the spectral efficiency to support the demand with fixed spectrum. Modulation formats of this type typically present difficulties for power amplification due to the statistics of the envelope of the signal, often referred to as peak-to-average power ratio or crest factor. Most client base stations employ Class A and Class AB amplifiers. The WiMAX era is erupting as several companies have already announced successful trails for 802.16-2004 (TDD) compliance. Most of the WiMAX base stations that are deployed have gaps in the coverage. In order to ensure quality of service (QOS), higher-power base stations are being developed to close the gaps and extend coverage. Examples of high-power base station transmitters with power averages of .9 watts and 5 watts are shown in *Figure 1* and *Figure 2* respectively.

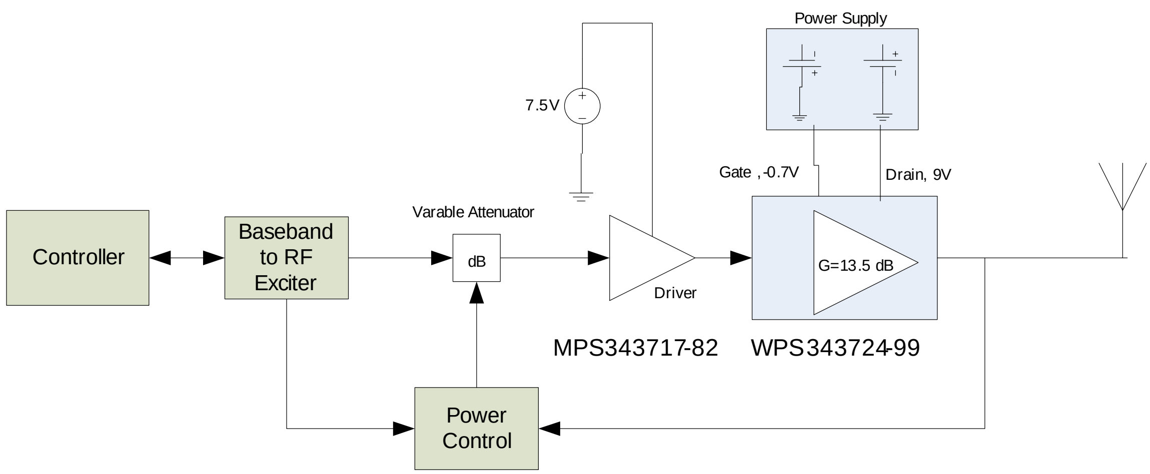


Figure 1: *Block diagram for a 0.9-watt (average) WiMAX transmitter.*

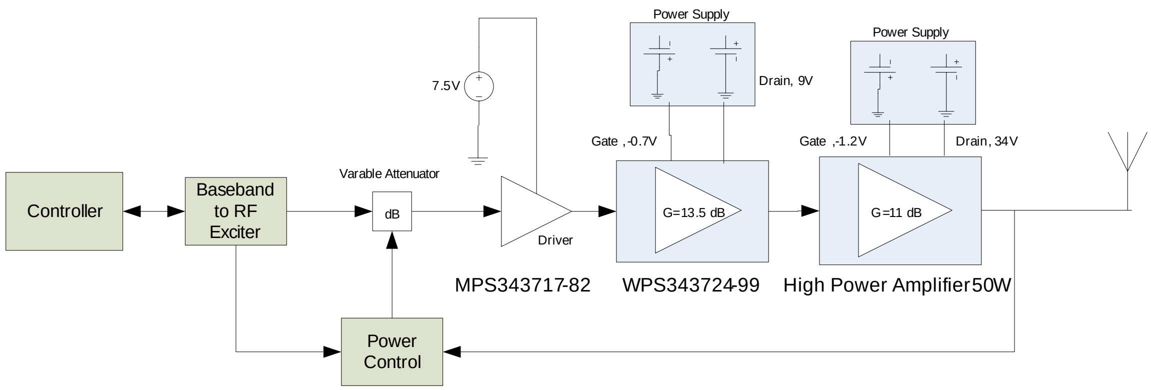


Figure 2: *Block diagram for a 5-watt (average) WiMAX transmitter.*

Since the semiconductor era uses III-V and IV elements, the RF amplifier technology has generated an array of devices. From Si-bipolar, to GaAs MESFET, to GaAs HBT, to silicon LDMOS, to GaAs HFET, and now wide bandgap devices such as SiC MESFET and, on the horizon, GaN HEMT devices, the choices for power amplifier technology is broad. The MESFET structure has been proven to be one of the best in linearity. While LDMOS structure does not compare in linearity, its power density is very attractive, as well as its high breakdown voltages. However, the silicon breakdown voltage can not match the breakdown voltage of SiC MESFET, which exceeds 100 volts. The advantage of the SiC MESFET is the materials property for high power density per unit area. The low trans-conductance property of SiC material has lower gain. Because of the wide bandgap properties of SiC, gain disadvantages are small in comparison to the high voltage and high output power operations. This paper proposes GaAs MESFET because of its excellent linearity and power gain. *Table 1* is a summary of the different processes.

Table 1: *Comparison Chart for Different Processes*

TYPE Process	Gain (2 GHz)	BreakdownVoltage	Gm (mS/mm)
GaAs MESFET	16	15	150
GaAs HFET	15.7	22	165
GaAs HBT	14.3	22	100[1]
LDMOS	15	75	200
SiC MESFET	15	100	100

At MwT, the GaAs process is engineered for high linearity and high power. WiMAX application at 3.3 to 3.8 GHz requires excellent error vector magnitude (EVM) and low spectral re-growth due to high crest factors. The block diagram in *Figure 1* is an example of a WiMAX transmitter where the driver and power amplifier assemblies are matched to

[1] Beta for GaAs HBT

50 ohms and together produce 29 dBm of average power at an error vector magnitude of 2.2%. The frame burst consists of four data bursts, BPSK, QPSK, 16-QAM, and 64-QAM, and a demodulator is allowed to synchronize to the preambles.

The WPS343724-99's gain is 13.0 dB and the flatness is +/- 0.3 dB. The amplifier module has a two tone linearity of IM3<50dBc and IM5<60dBc at 25 dBm per tone.

The output power of the amplifier is 17.4 dB higher than the measured power shown in *Figure 3*. A burst summary in *Figure 3* breaks down each modulation burst per EVM and output power. The total output power is 28 dBm for data burst EVM=1.5%. Increasing Vdd to 9 volts, the output power is 29 dBm for an overall EVM=2.0%.

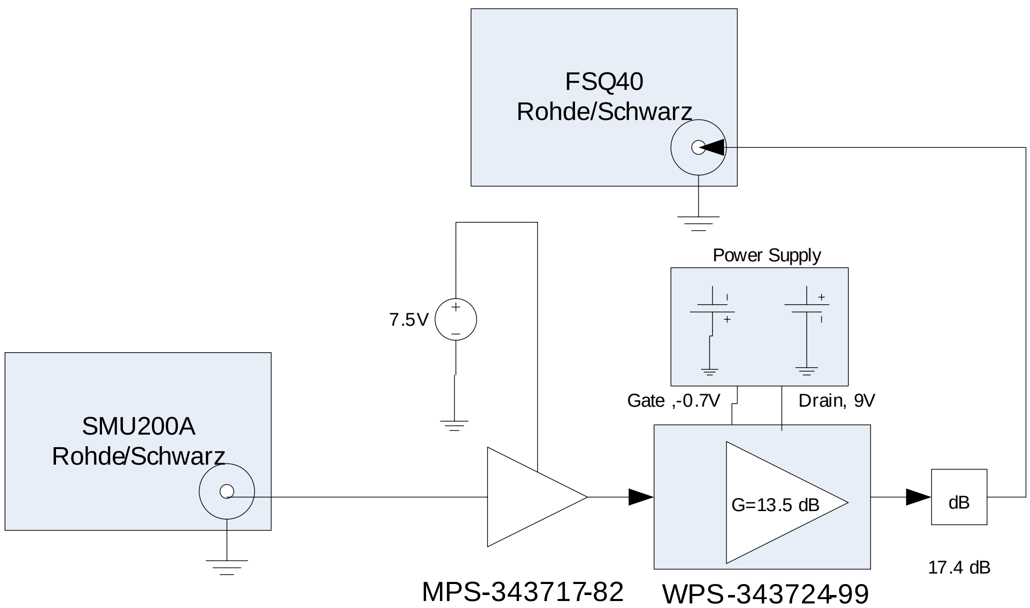


Figure 3: *Test Setup for WiMAX*

The pristine EVM and ACPR performance makes the MESFET structure an ideal choice for base stations designers. At MwT, the GaAs epi wafer has been designed for optimal linearity performance. The linearity of the WPS343724-99 is demonstrated in *Figure 4* where the average output power is 29.7 dBm and still the amplifier module has 3 dB margins to per ETSI 802.16-2004 mask. The drain DC-RF efficiency is better than most other high linear amplifiers at 7.4%.

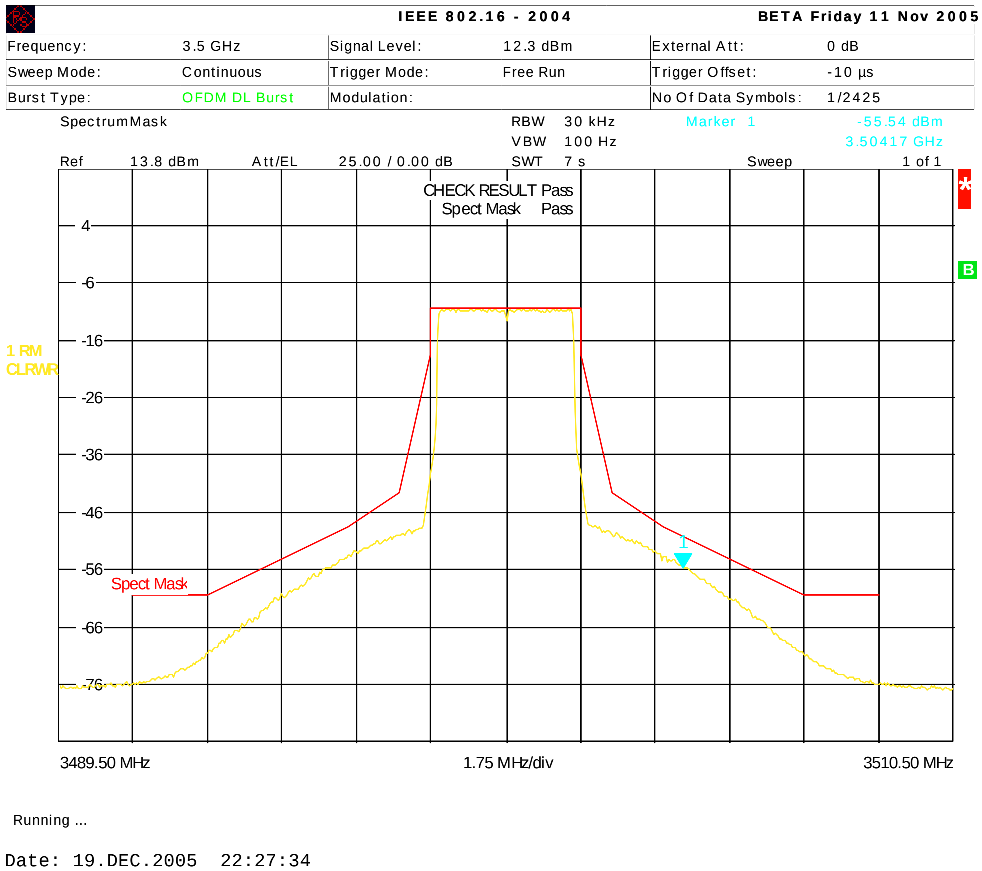
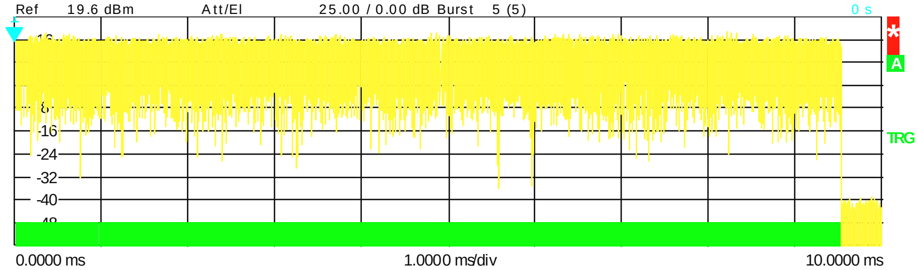


Figure 4: *Adjacent channel power ratio at Vdd=9 volts, Ptotal=29.7 dBm.*

The frame burst described in *Figure 5* and *Figure 6* is 9 milliseconds and continuous. The data bursts are BPSK, one symbol, QPSK, five symbols, 16-QAM, 30 symbols, and 64-QAM, 69 symbols. This table in *Figure 5* measures the average power and EVM respectively for each data burst. An overall output power and EVM is computed too. The amplifier bias voltage is Vdd=8 volts for the measurements in *Figure 5* and Vdd=9 volts in *Figure 6*.

IEEE 802.16 - 2004				BETA Friday 11 Nov 2005	
Frequency:	3.5 GHz	Signal Level:	9.6 dBm	External Att:	0 dB
Sweep Mode:	Continuous	Trigger Mode:	Power	Trigger Offset:	-10 µs
Burst Type:	OFDM DL Burst	Modulation:		No Of Data Symbols:	1/2425

Capture Memory No of Samples 40001 Marker 1
Capture Time 10 ms Gate Off 15.16 dBm
Ref 19.6 dBm Att/El 25.00 / 0.00 dB Burst 5 (5) 0 s



Burst Summary

Downlink Burst Summary List

Burst	Area	Modulation	Length[sym]	Power[dBm]	EVM[dB]
FCH	Preamble	BPSK	2	12.11	-40.21
	Data	BPSK	1	9.08	-35.12
Burst 2	Data	BPSK	9	9.08	-35.85
Burst 3	Preamble	BPSK	1	11.85	-39.64
	Data	QPSK	5	9.09	-37.73
Burst 4	Preamble	BPSK	1	11.86	-39.71
	Data	16QAM	30	9.11	-36.41
Burst 5	Preamble	BPSK	1	12.00	-39.91
	Data	64QAM	69	9.11	-36.53
Overall			119	10.60	-37.50

Running ...

Date: 19.DEC.2005 22:21:46

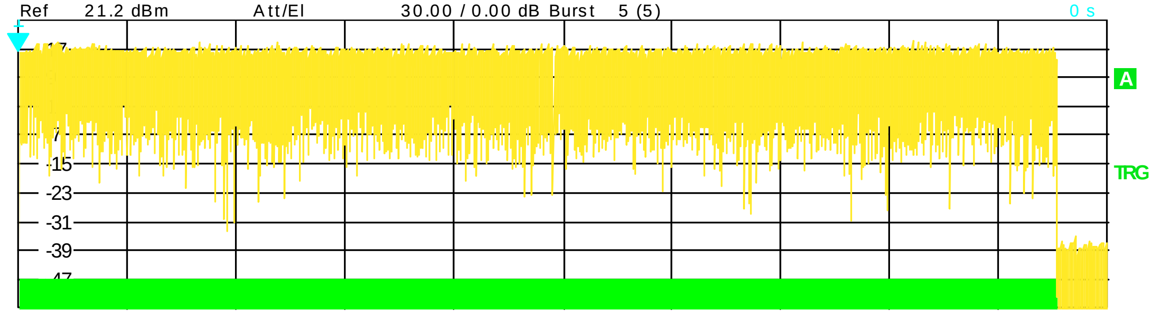
Figure 5: *Burst summary showing EVM and power Vdd=8 volts.*

IEEE 802.16 - 2004		BETA Friday 11 Nov 2005			
Frequency:	3.5 GHz	Signal Level:	11.2 dBm	External Att:	0 dB
Sweep Mode:	Continuous	Trigger Mode:	Power	Trigger Offset:	-10 µs
Burst Type:	OFDM DL Burst	Modulation:		No Of Data Symbols:	1/2425

Capture Memory   No of Samples 40001   Marker 1

Capture Time 10 ms   Gate Off   16.25 dBm

Ref 21.2 dBm   Att/El 30.00 / 0.00 dB   Burst 5 (5)   0 s



Burst Summary

Downlink Burst Summary List

Burst	Area	Modulation	Length[sym]		Power[dBm]
FCH	Preamble	BPSK	2	12.93	-39.26
	Data	BPSK	1	9.99	-31.67
Burst 2	Data	BPSK	9	10.01	-33.36
Burst 3	Preamble	BPSK	1	12.78	-40.04
	Data	QPSK	5	10.04	-35.95
Burst 4	Preamble	BPSK	1	13.01	-39.73
	Data	16QAM	30	10.04	-34.11
Burst 5	Preamble	BPSK	1	12.96	-39.44
	Data	64QAM	69	10.05	-34.00
Overall			119	11.55	-35.36

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Figure 6: *Burst summary showing EVM and power Vdd=9 volts.*

A plot of EVM (QAM-64) versus output power (QAM-64), taken every 1 dB step from 22 dBm to 28 dBm is shown *in Figure 7*. The test pattern used is PN9.

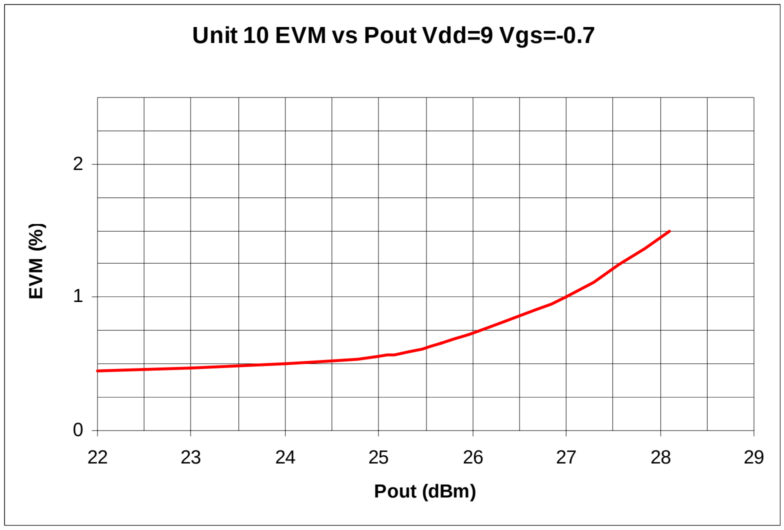

Figure 7: *EVM vs. power at Vdd=9 volts.*

For more information about the MwT WPS and MPS Series WiMAX products, please contact the MwT sales department at 510-651-6700 and/or your local sales representative.