APPLICATION NOTE #39C
AR RF/MICROWAVE INSTRUMENTATION "S" SERIES AMPLIFIERS PRODUCE HIGHER POWER, HIGHER FIDELITY SIGNALS FOR TESTING WIMAX OUTPUT DEVICES

Manufacturers of WiMAX output devices need a much larger signal than the typical Vector Signal generator can produce for WiMAX testing. These tests are done to verify the linearity of the amplifier device and the fidelity of the signal amplified. An amplifier is needed to produce these signals with sufficient power to do the testing while maintaining the original signal quality. The main limiting factor is the Peak Envelope Power (PEP) of the WiMAX signal. The peak power can be as much as 18 dB above the average power thus the need for amplification. There are two signal quality criteria that need to be maintained in this process, they are Adjacent Channel Power (ACP), Error Vector Magnitude (EVM) or Relative Constellation Error (RCE).

AR RF/Microwave Instrumentation offers three amplifier series that cover the frequency range of WiMAX. Very linear amplification is available from 800 MHz to 4.2 GHz (1 to 700 watts), another series that covers 4 to 8 GHz (15 to 120 watts) and a third series covers 4 to 10.6 GHz (1 to 80 watts).

Measurements were made for this application on two series AR amplifiers – 25S1G4A, 50S1G4A and 100S1G4 (25, 50 or 100 watts respectively, 0.8 to 4.2 GHz) and 15S4G8A and 35S4G8A (15 or 35 watts respectively, 4 to 8 GHz).

The test results show in figures 1 – 4 below verify that the signal generator produces a very high quality signal and the AR amplifiers reproduce these signals with remarkable fidelity. Measurements were made the 3.7 GHz and 5.8 GHz bands.

Figure 5 and 6 document the EVM versus power results for the same two series of amplifiers at the assigned WiMAX frequencies.

Figure 1: Model 50S1G4A at 3.7 GHz data

Input -17 dBm average power; Crest factor 10 dB

IEEE 802.16 - 2004					
Frequency:	3.7 GHz	Signal Level:	-15 dBm	External Att:	0 dB
Sweep Mode:	Continuous	Trigger Mode:	Free Run	Trigger Offset:	-10 µs
Burst Type:	OFDM DL Burst	Modulation:	64QAM3/4	No Of Data Symbols:	1/2425

Result Summary						
No. of Bursts	7					*
	Min	Mean	Limit	Max	Limit	Unit
EVM All Carriers	-49.64	-49.11	-31.00	-48.63	-31.00	dB
EVM Data Carriers	-49.61	-49.09	-31.00	-48.62	-31.00	dB
EVM Pilot Carriers	-50.29	-49.58		-48.64		dB
IQ Offset	-57.27	-57.10		-56.86		dB
Gain Imbalance	-0.00	-0.00		-0.00		dB
Quadrature Error	-0.073	-0.071		-0.070		°
Center Frequency Error	0.06	-0.09	±29600	-0.16	±29600	Hz
Symbol Clock Error	0.00	0.00	±8	-0.01	±8	ppm
Burst Power	-17.57	-17.56		-17.56		dBm
Crest Factor	9.74	9.74		9.75		dB
RSSI	-15.19	-15.19		-15.19		dBm
RSSI Standard Deviation		-33.91				dB
CINR	55.67	55.67		55.88		dB
CINR Standard Deviation		49.01				dB

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Output +30 dBm Average power; Crest factor 10 dB

IEEE 802.16 - 2004					
Frequency:	3.7 GHz	Signal Level:	3.1 dBm	External Att:	30 dB
Sweep Mode:	Continuous	Trigger Mode:	Free Run	Trigger Offset:	-10 µs
Burst Type:	OFDM DL Burst	Modulation:	64QAM3/4	No Of Data Symbols:	1/2425

Result Summary						
No. of Bursts	7					
	Min	Mean	Limit	Max	Limit	Unit
EVM All Carriers	-47.05	-46.63	-31.00	-46.14	-31.00	dB
EVM Data Carriers	-47.04	-46.62	-31.00	-46.12	-31.00	dB
EVM Pilot Carriers	-47.40	-46.81		-46.32		dB
IQ Offset	-58.04	-57.90		-57.72		dB
Gain Imbalance	-0.00	-0.00		-0.00		dB
Quadrature Error	-0.074	-0.072		-0.069		°
Center Frequency Error	-0.04	-0.07	±29600	-0.42	±29600	Hz
Symbol Clock Error	-0.00	0.00	±8	0.01	±8	ppm
Burst Power	30.42	30.43		30.43		dBm
Crest Factor	9.54	9.55		9.55		dB
RSSI	2.84	2.84		2.84		dBm
RSSI Standard Deviation		-16.21				dB
CINR	53.25	53.25		53.44		dB
CINR Standard Deviation		46.18				dB

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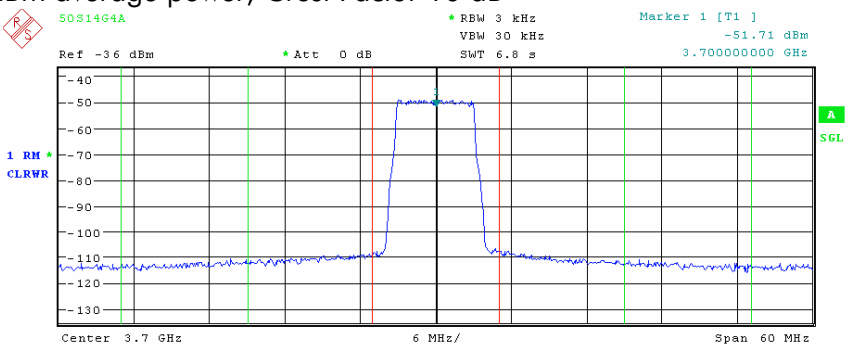
Figure 2: Model 50S1G4A at 3.7 GHz "Bartshead"

Input -17 dBm average power; Crest Factor 10 dB



Tx Channel			
Bandwidth	10 MHz	Power	-17.28 dBm
Adjacent Channel			
Bandwidth	10 MHz	Lower	-59.02 dB
Spacing	10 MHz	Upper	-58.77 dB
Alternate Channel			
Bandwidth	10 MHz	Lower	-61.29 dB
Spacing	20 MHz	Upper	-61.37 dB

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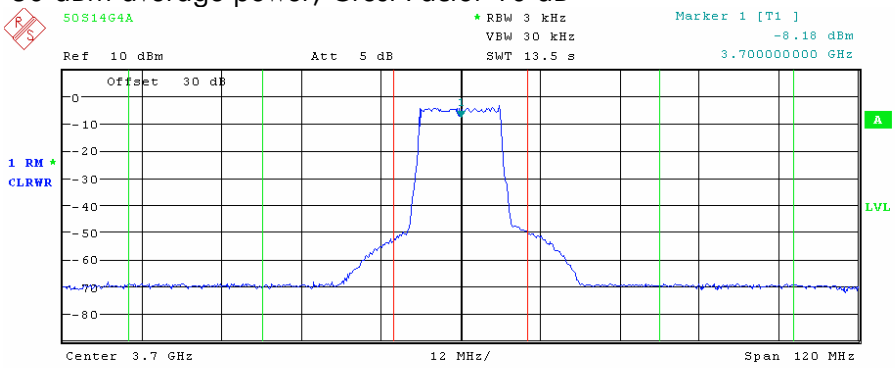
Output +30 dBm average power; Crest Factor 10 dB



Tx Channel			
Bandwidth	20 MHz	Power	30.42 dBm
Adjacent Channel			
Bandwidth	20 MHz	Lower	-53.85 dB
Spacing	20 MHz	Upper	-50.85 dB
Alternate Channel			
Bandwidth	20 MHz	Lower	-62.41 dB
Spacing	40 MHz	Upper	-62.56 dB

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Figure 3: Model 15S4G8A at 5.8 GHz data

Input -21 dBm average power; 10 dB Crest factor

IEEE 802.16 - 2004					
Frequency:	5.8 GHz	Signal Level:	-22.9 dBm	External Att:	0 dB
Sweep Mode:	Continuous	Trigger Mode:	Free Run	Trigger Offset:	-10 µs
Burst Type:	OFDM DL Burst	Modulation:	64QAM3/4	No Of Data Symbols:	1/2425

Result Summary						
No. of Bursts	7					*
	Min	Mean	Limit	Max	Limit	Unit
EVM All Carriers	- 47.80	- 47.50	- 31.00	- 46.95	- 31.00	dB
EVM Data Carriers	- 48.25	- 47.47	- 31.00	- 46.94	- 31.00	dB
EVM Pilot Carriers	- 49.11	- 48.11		- 47.19		dB
IQ Offset	- 51.42	- 51.29		- 51.00		dB
Gain Imbalance	- 0.01	- 0.00		- 0.00		dB
Quadrature Error	- 0.030	- 0.025		- 0.020		°
Center Frequency Error	0.04	0.27	± 46400	1.07	± 46400	Hz
Symbol Clock Error	0.00	- 0.00	± 8	- 0.02	± 8	ppm
Burst Power	-21.48	-21.47		-21.46		dBm
Crest Factor	9.81	9.82		9.82		dB
RSSI	- 24.08	- 24.08		- 24.08		dBm
RSSI Standard Deviation		- 39.07				dB
CINR	46.79	46.83		46.95		dB
CINR Standard Deviation		41.69				dB

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Output +24 dBm average power; 10 dB Crest factor

IEEE 802.16 - 2004					
Frequency:	5.8 GHz	Signal Level:	-3.2 dBm	External Att:	30 dB
Sweep Mode:	Continuous	Trigger Mode:	Free Run	Trigger Offset:	-10 µs
Burst Type:	OFDM DL Burst	Modulation:	64QAM3/4	No Of Data Symbols:	1/2425

Result Summary						
No. of Bursts	6					*
	Min	Mean	Limit	Max	Limit	Unit
EVM All Carriers	- 43.32	- 43.08	- 31.00	- 42.75	- 31.00	dB
EVM Data Carriers	- 43.24	- 43.03	- 31.00	- 42.88	- 31.00	dB
EVM Pilot Carriers	- 43.80	- 43.31		- 43.04		dB
IQ Offset	- 52.12	- 51.95		- 51.78		dB
Gain Imbalance	- 0.01	- 0.00		- 0.00		dB
Quadrature Error	- 0.032	- 0.029		- 0.025		°
Center Frequency Error	- 0.27	0.07	± 46400	- 0.59	± 46400	Hz
Symbol Clock Error	0.00	- 0.00	± 8	- 0.01	± 8	ppm
Burst Power	24.15	24.16		24.16		dBm
Crest Factor	9.79	9.79		9.80		dB
RSSI	- 3.49	- 3.49		- 3.49		dBm
RSSI Standard Deviation		- 21.72				dB
CINR	50.03	50.03		50.20		dB
CINR Standard Deviation		42.47				dB

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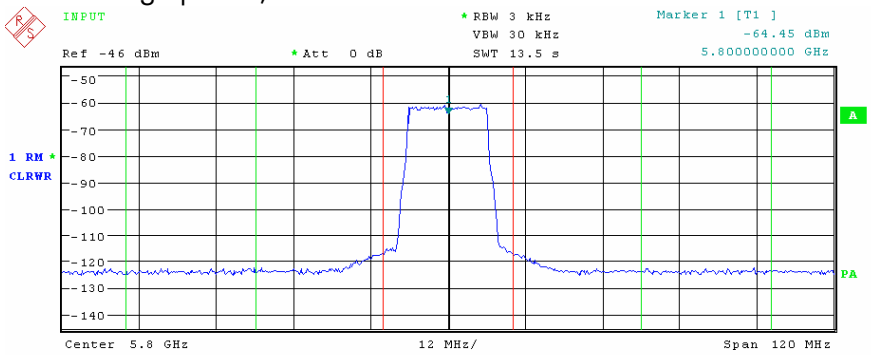
Figure 4: Model 15S4G8A at 5.8 GHz "Bartshead"

Input -21 dBm average power; Crest factor 10 dB



Tx Channel			
Bandwidth	20 MHz	Power	-26.35 dBm
Adjacent Channel			
Bandwidth	20 MHz	Lower	-57.94 dB
Spacing	20 MHz	Upper	-58.13 dB
Alternate Channel			
Bandwidth	20 MHz	Lower	-60.07 dB
Spacing	40 MHz	Upper	-59.99 dB

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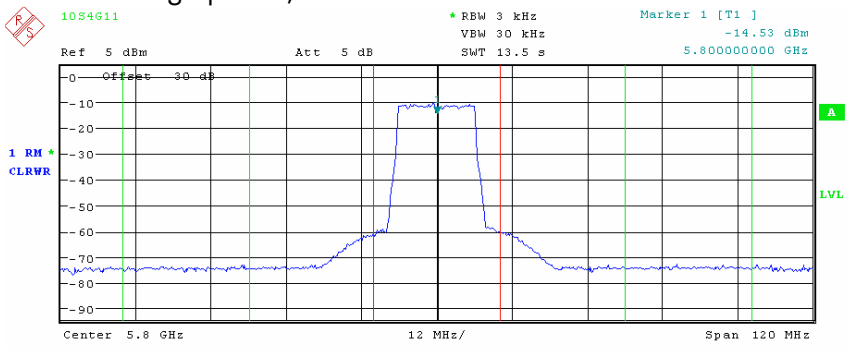
Output +24 dBm average power; Crest factor 10 dB



Tx Channel			
Bandwidth	20 MHz	Power	24.18 dBm
Adjacent Channel			
Bandwidth	20 MHz	Lower	-54.86 dB
Spacing	20 MHz	Upper	-54.00 dB
Alternate Channel			
Bandwidth	20 MHz	Lower	-61.26 dB
Spacing	40 MHz	Upper	-60.94 dB

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Previously, a key specification was the Third Order Intercept (TOI or IP3). This level helps define the linearity characteristics for any given amplifier – but this is not the entire story. The more important question is "how does the amplifier distort the vector modulated signal?" Error Vector Magnitude (EVM) is a more desirable and definitive measurement of an amplifier's performance.

One task that can be difficult to manage is selecting the "right size" amplifier. The "Power Rating" is not sufficient to determine whether any given amplifier will be suitable for a particular application. The figures below provide additional linearity data to help in this selection process. Some applications require lower EVM than others.

Figure 5:
EVM vs. Output Power
15S4G8A and 35S4G8A

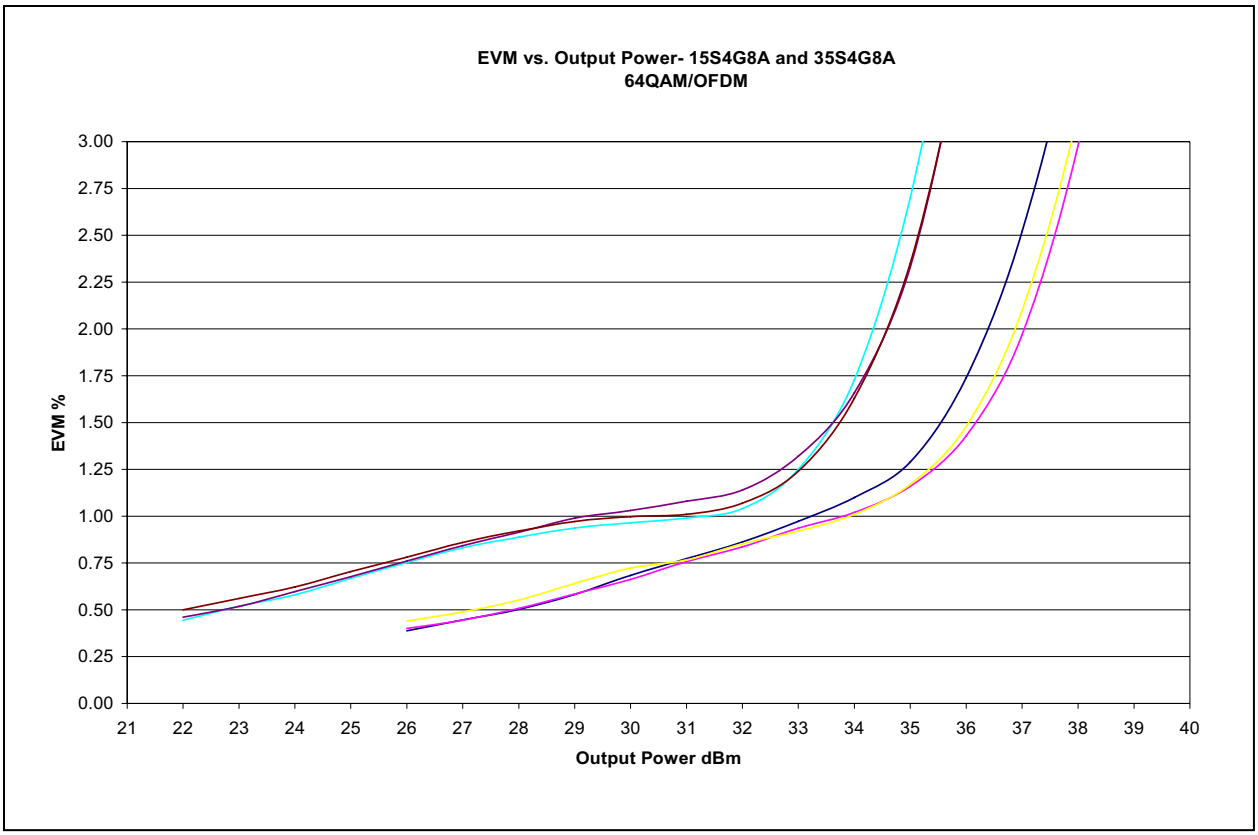

Figure 5:
EVM vs. Output Power
25S1G4A, 50S1G4A & 100S1G4

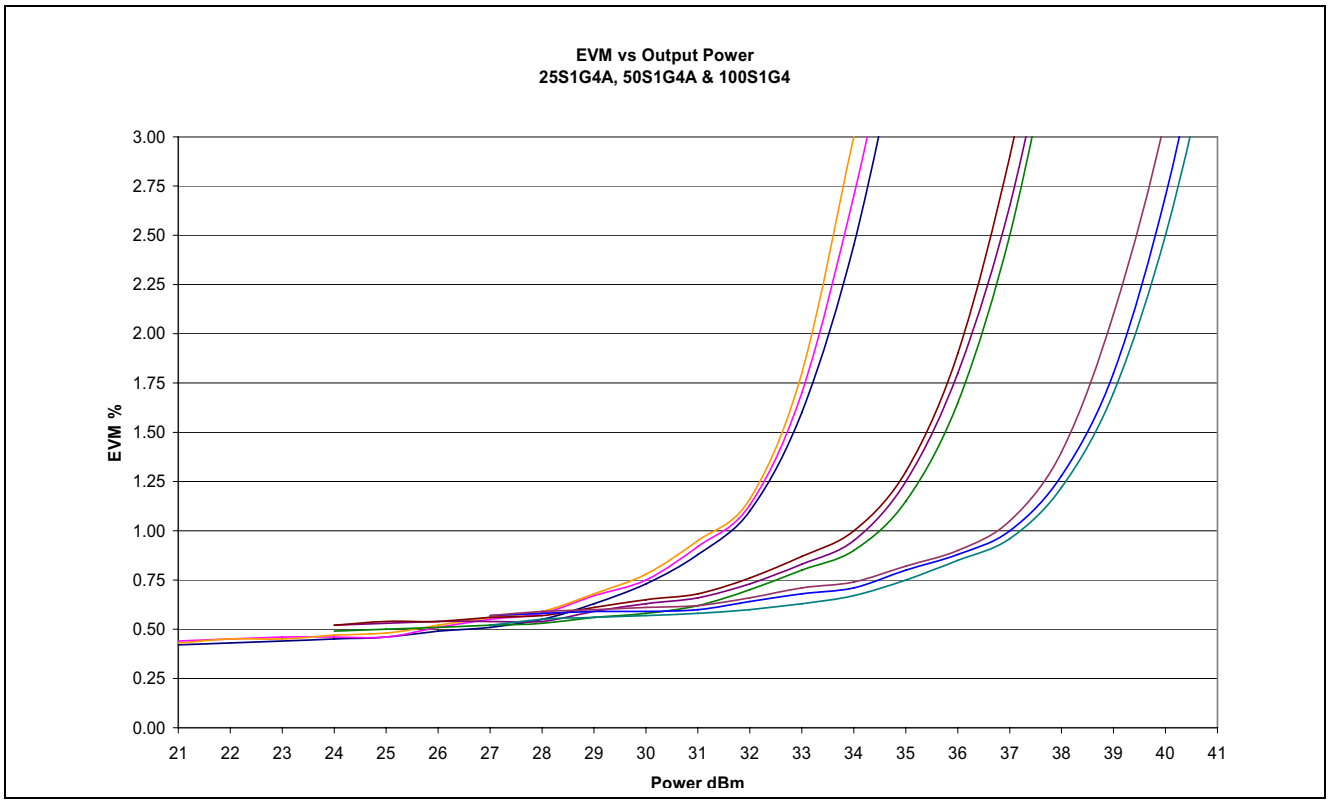

Figure 7 shows the "S" series amplifier models applicable for this application from AR RF/Microwave Instrumentation.

Figure 7

Model	Power & Frequency
1S1G4	1 watt CW, 0.8 – 4.2 GHz
5S1G4	6.5 watt CW, 0.8 – 4.2 GHz
10S1G4A	13 watt CW, 0.8 – 4.2 GHz
25S1G4A	25 watt CW, 0.8 – 4.2 GHz
50S1G4A	50 watt CW, 0.8 – 4.2 GHz
100S1G4	100 watt CW, 0.8 – 4.2 GHz
200S1G4A	200 watt CW, 0.8 – 4.2 GHz
400S1G4	400 watt CW, 0.8 – 4.2 GHz
540S1G4	540 watt CW, 0.8 – 4.2 GHz
700S1G4	700 watt CW, 0.8 – 4.2 GHz
15S4G8A	15 watt CW, 4 – 8 GHz
35S4G8A	35 watt CW, 4 – 8 GHz
60S4G8	60 watt CW, 4 – 8 GHz
90S4G8	90 watt CW, 4 – 8 GHz
120S4G8	120 watt CW, 4 – 8 GHz
1S4G11	1 watt CW, 4 – 10.6 GHz
5S4G11	5 watt CW, 4 – 10.6 GHz
10S4G11A	10 watt CW, 4 – 10.6 GHz
20S4G11A	20 watt CW, 4 – 10.6 GHz
40S4G11	40 watt CW, 4 – 10.6 GHz
60S4G11	60 watt CW, 4 – 10.6 GHz
80S4G11	80 watt CW, 4 – 10.6 GHz