1. WiMAX Device and System Operating Parameters

Table 1: 802.16e/WiMAX Device and System Operating Parameters

Description	Parameter	Comment
FCC ID	V7MSWU-3120	Identify all related FCC ID
Radio Service	PART 27	Rule parts
Transmit Frequency Range (MHz)	2506 ~ 2685MHz (5MHz OBW) 2506 ~ 2685MHz (10MHz OBW)	System parameter
System/Channel Bandwidth (MHz)	5 MHz or 10 MHz	System parameter
System Profile	Mobile WiMAX (802.16e-2005)	Defined by WiMAX Forum
Modulation Schemes	QPSK, 16QAM	Identify all applicable UL modulations
FFT Size (NFFT)	512 (5MHz), 1024 (10MHz)	(N_{FFT})
Sub-Carrier Spacing (kHz)	10.9375 (fixed)	(Δf)
Useful Symbol time (μs)	91.4286	(Tb=1/Δf)
Guard Time (μs)	11.43	(T_g=T_b/cp); cp = cyclic prefix
OFDMA Symbol Time (μs)	102.8586	(T_s=T_b+T_g)
Frame Size (ms)	5	System parameter
Number of DL OFDMA Symbols per Frame	29	Identify the allowed & maximum symbols, including both traffic & control symbols
Number of UL OFDMA Symbols per Frame	18	
DL:UL Symbol Ratio	29:18	For determining UL duty factor
Wave1 / Wave2	Wave1	Describe antenna diversity info and MIMO requirements separately Details in the Clause 1 of Annex
UL Zone Types (FUSC, PUSC, OFUSC, OPUSC, AMC, TUSC1, TUSC2)	PUSC and AMC	Describe separately the symbol and sub-carrier/sub-channel structures applicable to each zone type Details in the Clause 1 of Annex
Maximum Number of UL Sub-Carriers	768 (UL data Bursts of AMC)	Identify the allowed and tested / to be tested parameters; include separate explanations on the types of control symbols and how the power levels are determined. Details in the Clause 1, 3 of Annex
UL Burst Maximum Average Power	24.33 dBm	
Number and type of UL Control Symbols	3 Symbols of PUSC zone format only (CQICH, HARQ ACK/NACK)	
UL Control Symbol Maximum Average Power	18.37 dBm (5MHz/AMC) 15.36 dBm (10MHz/AMC)	
UL Burst Peak-to-Average Power Ratio (PAR)	~ 5.5 dB (10% CCDF)	Identify the expected range and measured/tested PAR; explain separately the methods used / to be used to address SAR probe calibration and measurement error issues Details in the Clause 6 of Annex
Frame Averaged UL Transmission Duty Factor (%)	30.86%	Show calculations separately and explain how the applicable CF *(crest factor)* used / to be use in the SAR measurements is derived and how the control symbols are accounted for Details in the Clause 2 of Annex

2. SAR Test Considerations

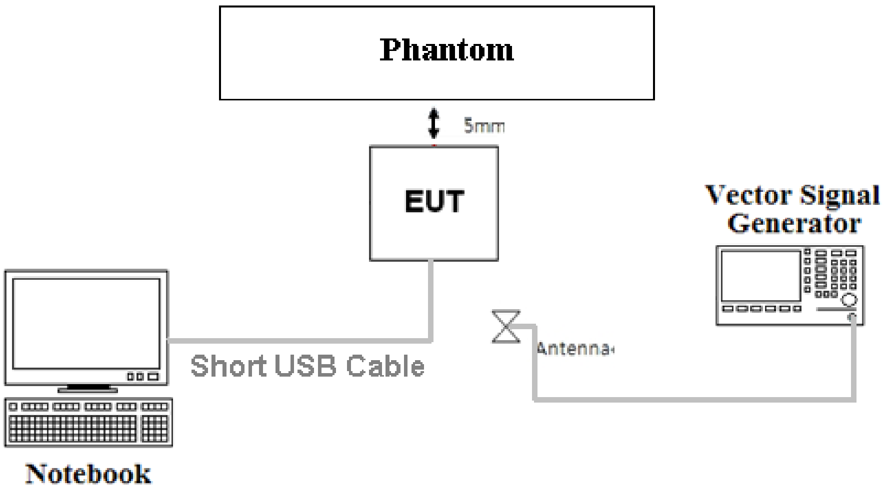
Table 2: Information on Test Equipment and Measurement Results

Equipment / Results	Description
Test Software	Describe the configuration details and test methodology, including test signal characteristics, similar to examples in the Annex. This is described in the Clause 1 of Annex
Signal Generator	
Communication Test Set	
SAR Test Signal Characteristics and Structure	Describe the test signal and data/burst structure used / to be used in the SAR tests. Explain why the system operating parameters, test software, signal generator, communication test set and other test configurations are chosen for evaluating the maximum exposure conditions. This is described in the Clause 2 of Annex
Output Power Measurement	Include average conducted power measurement results for the UL burst, at maximum duty factor, on high, middle & low channels for each modulation. Identify the control symbol configurations tested for SAR; include the measurement setup, any test software and signal generator setup details This is described in the Clause 3 of Annex
SAR Measurement Results	SAR results are not necessary for KDB/PBA inquiries on how a device should be tested. However, tabulated SAR results are necessary for PBA requests submitted by a TCB; a representative SAR plot should also be included to identify the measurement parameters such as the *crest factor* used for SAR conversion and other relevant information – probe, tissues. This is described in the Clause 4 of Annex
Other Relevant Parameters and Issues	Explain any other concerns specific to the test device should be addressed; for example, MIMO or non-standard WiMAX systems. N/A

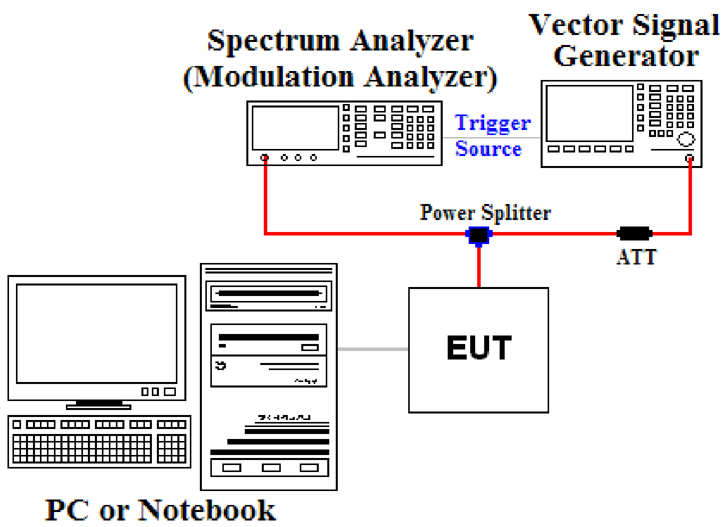
Annex : Details for measurement

1. Describe the configuration details and test methodology, including test signal characteristics.

The test set-up for SAR and RF conducted test are shown in the below picture. The WiMAX USB Modem (EUT) is connected to the USB port of the notebook computer using the short USB extension cable. The WCM v1.66 and the DM v1.95 test tool on the notebook computer are used for this SAR testing. The WCM test tool is just for display connection status between notebook computer and EUT. The DM test tool is used to control maximum transmitting power, frequency selection and TX/RX status.
The EUT uses 29:18 WiMAX frame (Downlink : Uplink Symbols). Currently this is the maximum duty for WiMAX device for BRS/EBS operators. This WiMAX frame is selected using the specific downlink waveform in the VSG (Vector Signal Generator).



Test set up for SAR



Test Set Up for RF conducted test

This EUT is a 2.5 GHz WiMAX transceiver using GCT chipset which supports antenna structure for 1 TX and 2 RX. Only one antenna is used for both transmitting and receiving while the other antenna is strictly used for RX diversity. The EUT has capable of both 10 MHz and 5 MHz uplink bandwidths. For the 10 MHz bandwidth of AMC zone format, it has 48 sub-channels structured from 1024 subcarriers; 160 are used as spare/safeguard subcarriers, leaving 864 available for transmission. From this, 768 subcarriers for data transmission with 96 subcarriers intended for pilot use.

For the 5 MHz bandwidth of AMC zone, it contains 24 sub-channels using 512 subcarriers; 80 subcarriers as spare/safeguard subcarriers, 384 for data transmission, and 48 for pilot.
The up-link sub-frame is triggered by an Allocation Start Time contained in the information of UL-MAP. This information specifies the starting times of the Uplink and Downlink frames. In any UL sub-frame, the duty factor ranging and bandwidth information is used to ensure optimal system operation. In normal transmission, the device will transmit control signaling at the first 3 uplink symbols and then use the rest of the uplink symbols for data traffic bursts in the uplink sub-frame.

Since the first 3 symbols are also used for ranging detection purposes and are shared among other devices , its transmitting power is much smaller than the data burst symbol power. During the SAR testing, the first 3 symbols are also kept in reduced power level and the data traffic bursts are always running at the maximum output power level. In the real usage, the data burst power will be adjusted according to the signal strength of the communication.

The VSG produces a downlink burst every 5 milliseconds which simulates the transmission of a BS operating under normal mode. This downlink burst instructs the MS to transmit for 15 symbols in the UL data zone. This UL transmission is repeated every 5 milliseconds. The transmitting power of the MS is set to maximum power.

The VSG and MS use same frequency. The VSG level is much less than the MS TX power (Approximately 80dB less than the MS power) and so does not affect the SAR readings. Since both the VSG (Base station simulator) and MS are working in TDD mode, co-operation under same frequency is not an issue.

The VSG is loaded with a BS (Base Station) downlink signal which contains the 29:18 information. The mobile station synchronizes to the signal from the VSG in frequency and time and then demodulates two maps contained in the VSG DL frame. The first map, called the DL map, specifies the number of DL symbols(29). The second map, called the UL map, specifies the number of UL symbols(18). The UL map also tells the MS to transmit a burst which occupies all data symbols and all sub-channels. No control channel transmissions are requested by the VSG. Measurements were taken in this configuration with the MS transmitting using the 29:18 ratio, but since there was no energy in the control symbols, the effective power is only across 15 data symbols.

As mentioned above the DL:UL frame is specified in the DL and UL maps respectively. There is no ranging present when there is data traffic. The other types of control traffic are HARQ ACK/NACK, CQICH(CINR reporting) and bandwidth(BW) requests. BW requests are piggy-backed onto the data symbols when traffic is present. Since the BW requests are shared across the Control Symbols (traffic versus non-traffic modes) and control symbols can be supported only in PUSC zone format, the control traffic that is relevant to the SAR calculation is CQICH and HARQ ACK/NACK. So the conducted maximum power for this control traffic is 5/35 of 240.4 mW(23.81 dBm) for 10 MHz and 5/17 of 233.3 mW(23.68 dBm) for 5 MHz.

In the test mode of AMC zone format, the UL operates with all data sub-channels(48 sub-channels for 10MHz) occupied with data. During normal operation the MS will transmit on all sub-channels when maximum UL throughput is required. It is possible for the MS to will transmit fewer sub-channels

For the signal from the VSG, it looks identical to the signal that would come from a BS in the field. The intent is to make the think it is in EUT a real network. The transmission from the EUT under test conditions is exactly the same as in the field in normal operation. The only difference is that normally in the field there will be information in some of the control symbols, whereas SAR tests were performed with not having the information in the some control symbols. So it is necessary to calculate a scaling factor that takes into consideration this fact.

You will see a calculation, scaling factor from the measurements (the measurements were taken under a channel configuration of 29:18, without control symbols) to a network configuration using 29:18. This is also calculated for 10MHz and 5MHz bandwidth channels.

2. Describe the test signal and data/burst structure used / to be used in the SAR tests. Explain why the system operating parameters, test software, signal generator, communication test set and other test configurations are chosen for evaluating the maximum exposure conditions.

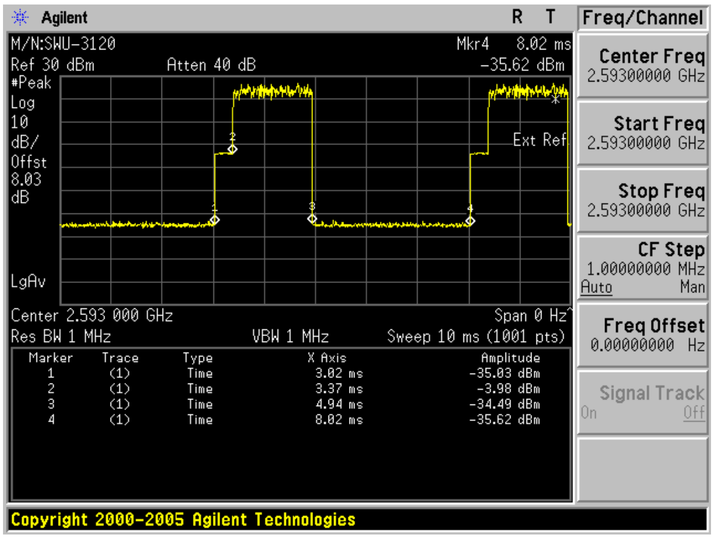
The testing was done using a common 29:18 ratio as described in clause 1 of this Annex. The 29 indicates the number of downlink (from the base station) symbols, and the 18 indicates the number of uplink (transmitted from the MS) symbols. Inside the uplink, 15 of the symbols are used for data, and three of the symbols are used for sending control information to the network. During the testing, the control symbols contained no information, so did not contribute to the total energy transmitted. The correct duty factor should be (15*102.8586 uS)/5000 uS=30.86 %. According to below actual plots of this device,
Frame length (Plot 1) = Mark 4 – Mark 1 = 8.02 ms – 3.02 ms = 5 ms
15 uplink data symbol length (Plot 2) = Mark 3 – Mark 2= 4.944 ms-3.384 ms = 1.56 ms
So Duty cycle = 1.56 / 5 * 100 % = 31.2 %
This agrees with the above calculated duty cycle (30.86%) of this device.

Using this calculation method eliminates all the other transmit time, guard time, etc, and only uses the transmit time.

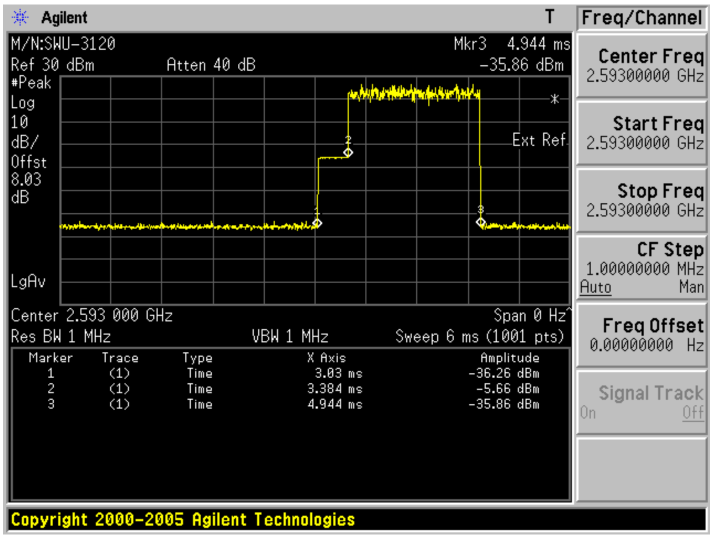
Regarding to why these numbers don't total to 48: Since AMC is dominant, this determines the allowed DL:UL ratios. In DL AMC, bursts require two symbols so DL symbol count must be an even number+1 symbol for the preamble. Hence the number of DL symbols must be an odd number. In the UL, AMC bursts require 3 symbols so UL must be a multiple of three symbols. In addition, the total number of symbols(DL+UL) is chosen to be 47 or less to allow for sufficient time to switch between DL and UL and vice versa.

There is a quiet time between the DL and UL transmission and a quiet time between the UL and DL transmission. During these quiet intervals the Base Station is neither transmitting nor receiving. The unoccupied symbols become part of this quiet time.

Ranging is performed to make sure the MS transmits in the correct time window. Data transmission is disabled when the MS is ranging. This is done to prevent the MS from transmitting at the wrong time and interfering with other users. Hence the MS is not allowed to range and transmit data at the same time. So ranging was not considered in the scaling factor.



Plot 1



Plot 2

Uplink burst for 29:18 symbol ratio with control symbol inactive

3. Include average conducted power measurement results for the UL burst, at maximum duty factor, on high, middle & low channels for each modulation. Identify the control symbol configurations tested for SAR; include the measurement setup, any test software and signal generator setup details

The maximum average conducted output power is measured for the uplink burst in the different modulations. The same setup and device operating configurations used for SAR measurement are also used for the power measurements. Power is measured with a spectrum analyzer (Agilent PSA Series E4440A) and the device is connected to the vector signal generator through a directional coupler. The external trigger source of VSG was connected to spectrum analyzer. The average power is measured using the integrating power function of the spectrum analyzer for the uplink bursts through triggering and gating.

Bandwidth	Zone Format	Frequency (MHz)	QPSK 1/2 (dBm)	QPSK 3/4 (dBm)	16QAM 1/2 (dBm)	16QAM 3/4 (dBm)
5MHz	PUSC	2506	23.50	23.34	23.68	23.46
		2593	23.60	23.50	23.51	23.35
		2685	22.60	22.57	22.43	22.23
	AMC	2506	**24.14**	24.13	**24.11**	24.07
		2593	**24.10**	24.06	**23.99**	23.88
		2685	**23.41**	23.26	**23.42**	23.15
10MHz	PUSC	2506	23.81	23.75	23.73	23.62
		2593	23.58	23.42	23.45	23.42
		2685	22.75	22.66	22.65	22.45
	AMC	2506	**24.33**	24.27	**24.25**	24.15
		2593	**23.89**	23.80	**23.71**	23.68
		2685	**23.32**	23.25	**23.27**	23.19

Maximum average power table during the data bursts on period

4. SAR results are not necessary for KDB/PBA inquiries on how a device should be tested. However, tabulated SAR results are necessary for PBA requests submitted by a TCB; a representative SAR plot should also be included to identify the measurement parameters such as the *crest factor* used for SAR conversion and other relevant information – probe, tissues.

SUMMARY OF SAR TEST RESULTS (Details in the SAR test report)

- SUMMARY OF SAR TEST MODE

TEST MODE	COMMUNICATION	MODULATION TYPE & CODING RATE NOTE 1	Zone Format	ASSESSEMENT POSITION	TESTED CHANNEL
1	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	A	M
2	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	B	M

3	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	C	M
4	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	D	M
5	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	E	L,M,H
6	WiMAX-5 M,10 M	16QAM 1/2, QPSK 1/2	AMC	F	M

Note 1 : According to the conducted power table, above modulation types, coding rates and AMC zone format are selected for the worst case SAR test. Also 29 :18 frame structure is selected for the SAR tests.

- BANDWIDTH: 5 MHz (Before Scaled)

	MEASURED VALUE OF 1 g SAR (W/Kg)											
TEST MODE	1		2		3		4		5		6	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
LOW CHANNEL	-	-	-	-	-	-	-	-	-	0.623	-	-
Middle CHANNEL	0.200	0.210	0.239	0.242	0.039	0.039	0.166	0.166	0.374	0.382	0.026	0.026
High CHANNEL	-	-	-	-	-	-	-	-	-	0.640	-	-

- BANDWIDTH: 10 MHz (Before Scaled)

	MEASURED VALUE OF 1 g SAR (W/Kg)											
TEST MODE	1		2		3		4		5		6	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
LOW CHANNEL	-	-	-	-	-	-	-	-	-	**0.707**	-	-
Middle CHANNEL	0.284	0.292	0.226	0.224	0.034	0.036	0.173	0.170	0.400	0.411	0.039	0.038
HIGH CHANNEL	-	-	-	-	-	-	-	-	-	0.699	-	-

- BANDWIDTH: 5 MHz (After Scaled)

	SCALED VALUE OF 1 g SAR (W/Kg)											
TEST MODE	1		2		3		4		5		6	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
SCALING FACTOR	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
LOW CHANNEL	-	-	-	-	-	-	-	-	-	0.660	-	-
Middle CHANNEL	0.212	0.223	0.253	0.257	0.041	0.041	0.176	0.176	0.396	0.405	0.028	0.028
High CHANNEL	-	-	-	-	-	-	-	-	-	**0.678**	-	-

- BANDWIDTH: 10 MHz (After Scaled)

	MEASURED VALUE OF 1 g SAR (W/Kg)											
TEST MODE	1		2		3		4		5		6	
MODULATION TYPE	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK	16QAM	QPSK
SCALING FACTOR	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
LOW CHANNEL	-	-	-	-	-	-	-	-	-	**0.728**	-	-
Middle CHANNEL	0.293	0.301	0.233	0.231	0.035	0.037	0.178	0.175	0.412	0.423	0.040	0.039
HIGH CHANNEL	-	-	-	-	-	-	-	-	-	0.720	-	-

SAR Scaling Factor Calculations

According to the supplied product information, basically the SAR test was performed at 29:18 (18 uplink symbols per frame with 15 data symbols) as the worst case. When performing the SAR tests using the VSG, it looks identical to the signal that would come from a BS in the field. The intent is to make the think it is in EUT a real network. The transmission from the EUT under test conditions is exactly the same as in the field in normal operation. The only difference is that normally in the field there will be information in some of the control symbols, whereas SAR tests were performed with not having in the some control symbols. Therefore it is necessary to calculate a scaling factor that takes into consideration this fact. The calculation of this scaling factor is described in the followings.

For a 5MHz channel

For the 29:18 frame the UL consists of 18 symbols.

The first three symbols are control channels (BS signaling) and the remaining 15 symbols are for data.
Since PUSC zone only support control signal, the first 3 symbols have a total of 17 slots in a 5 MHz channel bandwidth. The maximum number of control slots that an active can occupy in any frame is:

(A) 2 slots for CQICH report-maximum of 2 simultaneous CQICH reports are allowed by the Standard from any MS
(B) 3 slots for HARQ ACK/NAK (5 ACK/NAK bits corresponding to maximum of 5 DL HARQ bursts in previous DL frame allowed by the standard - each HARQ ACK/NAK bit is transmitted using 1/2 slot)

These 5 slots occupy 5/17 of the total number of available UL slots.
If the UL data burst is transmitted at full power (23.68 dBm in PUSC zone), then the control channels using 5/17th the total number of slots transmitting at the maximum power should use :

23.68 dBm – 10 log(17/5) =(23.68- 5.32) dBm=18.37 dBm= 68.71 mW.

BW requests from the MS to the BS are piggy-backed on the data symbols if the MS is transmitting in the frame.
For using a 5 MHz channel using the maximum 68.71 mw for each control symbol, and 233.35 mW on the data symbols, the math is as follow:

On the 29:18(15 data symbols are used)
Scaling Factor = (3*68.71+15*233.35)/(15*233.35)=1.06
So the worst case SAR value can be compensated as below.
0.640*1.06=0.6784 mW/g

For a 10 MHz channel
For the 29:18 frame the UL consists of 18 symbols.

The first three symbols are control channels (BS signaling) and the remaining 15 symbols are for data.
Since PUSC zone only support control signal, the first 3 symbols have a total of 35 slots in a 10 MHz channel bandwidth. The maximum number of control slots that an active can occupy in any frame is:

(A) 2 slots for CQICH report - maximum of 2 simultaneous CQICH reports are allowed by the Standard from any MS
(B) 3 slots for HARQ ACK/NAK (5 ACK/NAK bits corresponding to maximum of 5 DL HARQ bursts in previous DL frame allowed by the standard - each HARQ ACK/NAK bit is transmitted using 1/2 slot)

These 5 slots occupy 5/35 of the total number of available UL slots.

If the UL data burst is transmitted at full power (23.81 dBm in PUSC), then the control channels using 5/35th the total number of slots transmitting at the maximum power should use 23.81 dBm-10log(35/5)=(23.81-8.45) dBm=15.36 dBm=34.36 mW.

BW requests from the MS to the BS are piggy-backed on the data symbols if the MS is transmitting in the frame.
For a 10 MHz channel using the maximum 34.36 mW for each control symbol, and 240.43 mW on the data symbols, the math is as follow:

On the 29:18 (15 data symbols are used)
Scaling Factor = (3*34.36+15*240.43)/(15*240.43)=1.03
So the worst case SAR data can be compensated as below

0.707*1.03=0.728 mW/g

Currently 29:18 (Downlink / Uplink Ratio) is the maximum duty for WIMAX device. Since US WiMAX operators in the BRS/EBS band have agreed to operate with 29 OFDMA symbols downstream and 18symbols upstream. US operators are working through the Wireless Communications Association International(WCA)to finalize a US best practices document including this ratio. The proposal has been approval at the WCA working group level and is awaiting final approval by the Board of Directors.
Therefore other duty (downlink : uplink ratio) is not considered for SAR test for this device.

5. Explain any other concerns specific to the test device should be addressed; for example, MIMO or non-standard WiMAX systems.

None

6. PAR and SAR Error Considerations

The SAR probe used for the measurements is calibrated with a sinusoidal CW signal. Since the DL:UL symbol ratio configuration allows a periodic uplink burst, the duty factor can be compensated by selecting the correct crest factor (CF) for the SAR measurement. If the duty factor were non-periodic, compensation is typically not possible and substantial SAR measurement error could be expected. The high peak-to-average power ratio (PAR) of OFDM/OFDMA is expected to introduce additional SAR measurement errors because the SAR probe is not calibrated for this type of random noise-like signals with large amplitude variations within the burst. This SAR error is also expected to vary with both the average power and average PAR at each measurement point, temporally and spatially. In order to estimate the measurement error due to PAR issues, the configuration with the highest SAR in each channel bandwidth and frequency band is measured at various power levels, from approximately 10 mW, at 3 dB steps, until the maximum power level is reached. As shown by the results and plot below, SAR is linear to power only when the probe sensors are operating within the square-law region. As power continues to increase, the measured SAR error becomes increasingly larger. Since these are single point peak SAR values measured with the probe positioned at the peak SAR location, at 2 mm from the phantom surface; therefore, the values are substantially higher than the 1-g SAR required to determine compliance. The results indicate that at approximately 200 mW SAR could be overestimated by 0.5 %. Since this type of measurement error is dependent on the signal characteristics, the results demonstrate that there is no SAR underestimation.

Average Power(mW)	13.7	27.5	50.8	103.3	194.5
Single Point SAR(W/Kg)	0.115	0.238	0.512	0.985	1.930

Regression analysis for SAR Probe Linearity Check