Ad hoc MIF Investigation

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Purpose and Outline

The purpose of this investigation is threefold:

•To verify the functionality of the RF Audio Interference Level Test Interface (henceforth “Tester Box”) developed by Steve Julstrom.

•To use the Tester Box to measure the Modulation Interference Factor (MIF) of several modulated signals of interest. These results are then compared to measurements of MIF using a fast-sensing average power meter and the weighting function of the Tester Box, carried out per the proposed MIF measurement procedure.

•To provide a comparison of the performance of the phone samples to the proposed standard (C63.19 Draft 1.8) versus the current standard (C63.119-2007), using the MIF data generated from the measurements above.

Note that all measurements taken in this investigation are accomplished through conducted coupling.

The presentation order is as follows:

•Equipment and Setup

•Verification Measurements using the Tester Box

•MIF measurements

•Phone performance comparisons

•References and Revision History

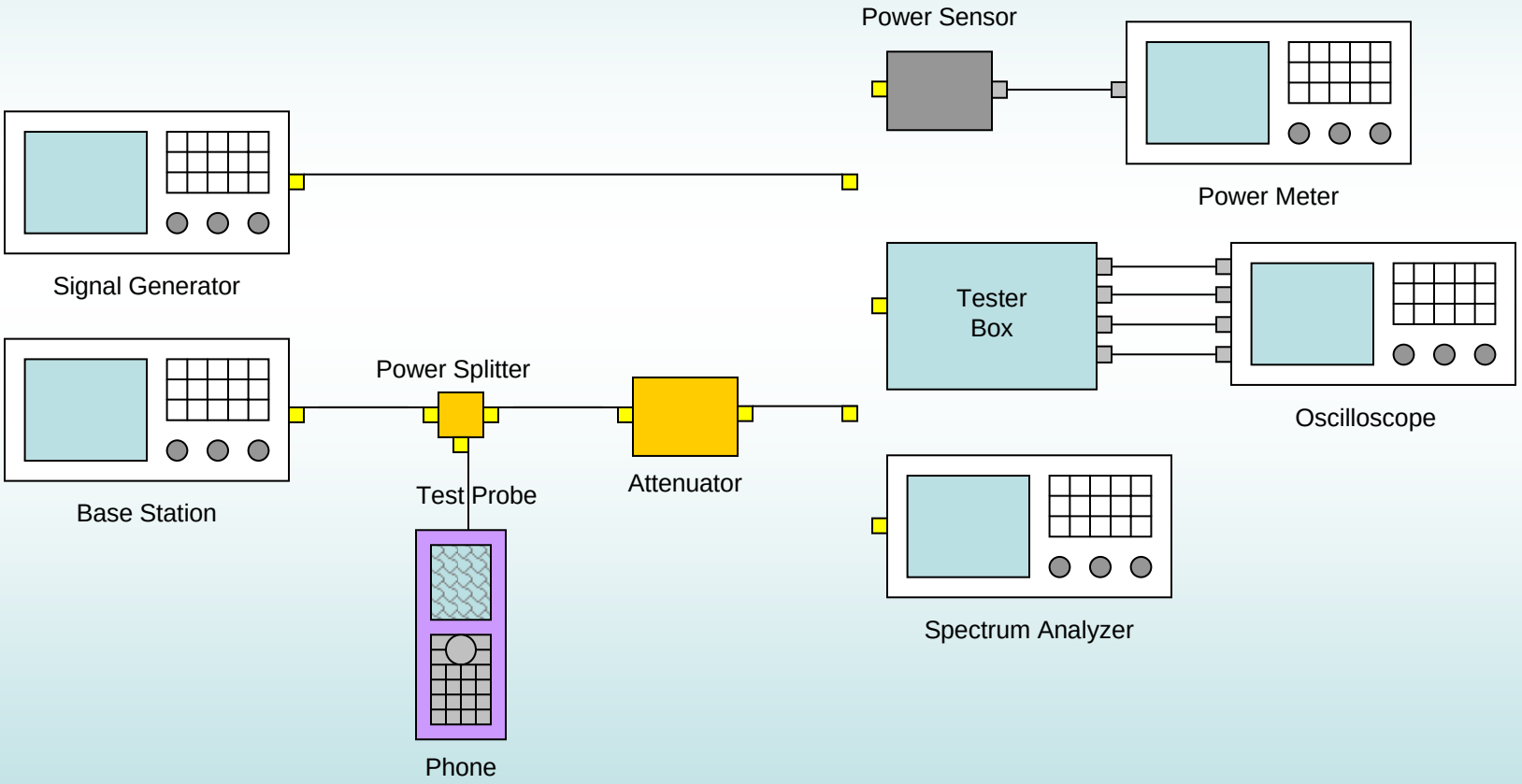
Equipment and Setup

The proceeding investigation uses the test equipment tabulated below. Functionally identical equipment may be substituted as necessary.

Equipment Name	Quantity	Designator
Agilent 8960 Series 10 Wireless Communications Test Set	1	Base Station
HP E4432B ESG-D Series Signal Generator	1	Signal Generator
Agilent N1912A P-Series Power Meter	1	Power Meter
Agilent N1921A Wideband Power Sensor	1	Power Sensor
Tektronix TDS 420A Four-Channel Digitizing Oscilloscope	1	Oscilloscope
HP 8595E Spectrum Analyzer	1	Spectrum Analyzer
Agilent 8495B Attenuator (Variable Attenuation)	1	Attenuator
Mini-Circuits ZAPD-21 Coaxial Power Splitter/Combiner	1	Power Splitter
Micro-Coax UFA210B Low Loss Cable Assembly	4	(Not designated)
Belden 8259 RG-58 A/U Cable Assembly	4	(Not designated)
RF Audio Interference Level Test Interface	1	Tester Box
Murata MXGS83RK3000 Microwave Test Probe	1	Test Probe
Various N-Type and SMA connector adapters	As Needed	(Not designated)

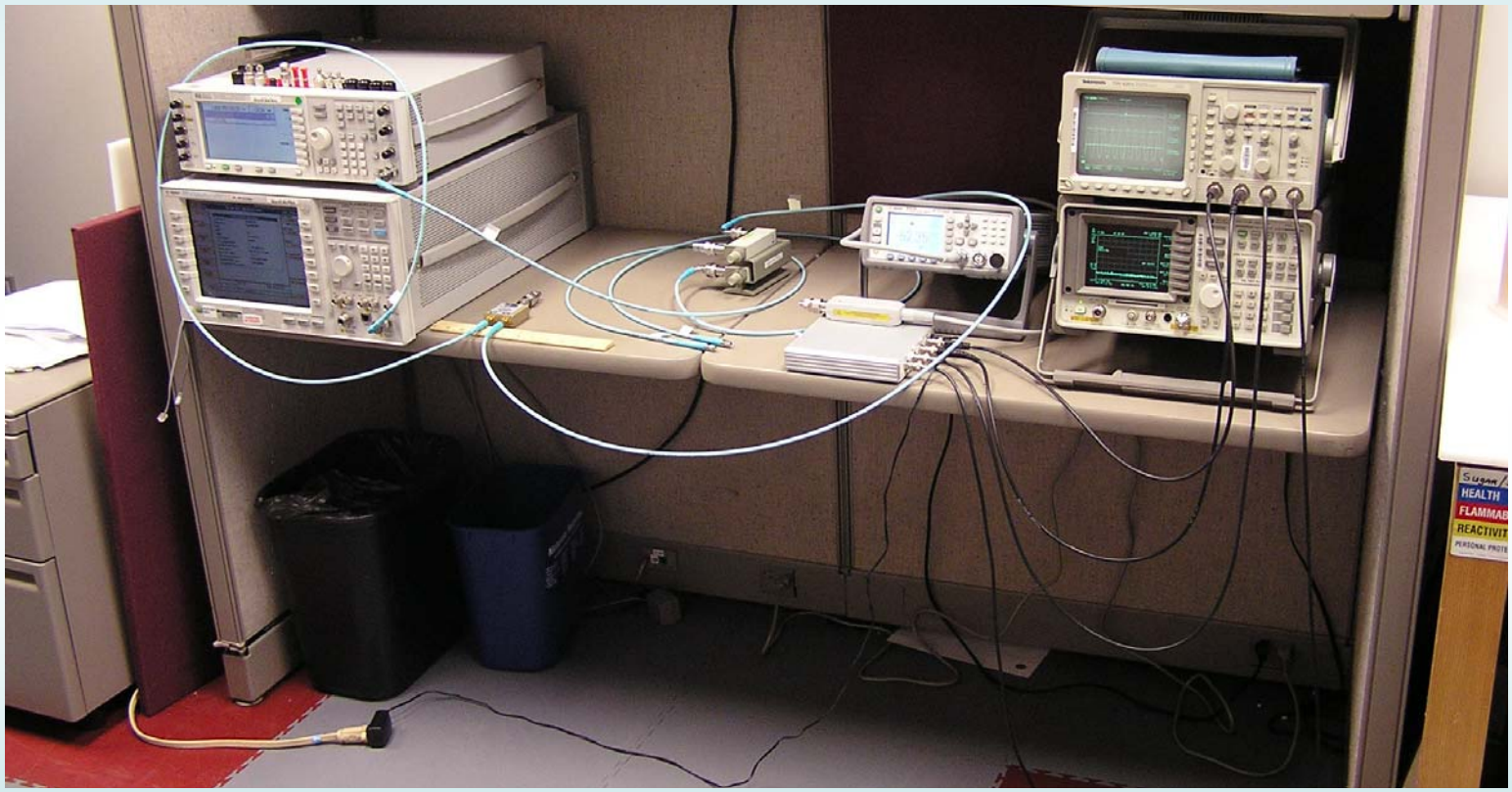
Equipment and Setup

The equipment is connected as shown below, using connector adapters where necessary. The cables from the Signal Generator and Base Station/Phone/Attenuator lineup are connected interchangeably with the Tester Box/Oscilloscope and Power Sensor/Power Meter lineups to conduct measurements. The Spectrum Analyzer is provided for reference, to double-check operation at the correct frequencies for Base Station/Phone setup.



Equipment and Setup

Setup as pictured.



Verification Measurements using the Tester Box

The intent of these measurements is to ensure the expected functionality of the Tester Box using the reference signal defined in the Tester Box's spec sheet. The reference signal is a carrier at the frequency of interest, 80% amplitude modulated by a 1 kHz baseband signal. To conduct these measurements the Signal Generator, Power Meter/Sensor, and Tester Box/Oscilloscope lineups are used according to the following steps:

- Connect the Signal Generator to the Tester Box.
- Command the Signal Generator to provide an 1 kHz 80% AM signal at the frequency of interest, and at a power level at the mid-point of the Tester Box's operating range.
- Record the four outputs of the Tester Box as measured by the Oscilloscope.
- Disconnect the Signal Generator from the Tester Box, and connect it to the Power Meter/Sensor.
- Record the average power of the signal as measured by the Power Meter/Sensor.
- Command the Signal Generator to remove the modulation. Record the average power of the unmodulated carrier.

The expected results are as follows:

- A measured value of -120 mV at the MIF Output of the Tester Box, equating to a -1.2 dB MIF for the 80% AM signal.
- A calculated difference of -1.2 dB between the power measurements of the modulated and unmodulated carrier, corresponding to the same -1.2 dB MIF.

Verification Measurements using the Tester Box

Measurements:

Signal Generator Mode	Frequency (MHz)	Tester Box				Power Meter Avg PW (dBm)
		Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)	
1 kHz 80% AM	835	147	148	110.4	-124	-24.46
CW	835					-25.65
				MIF (dB):	-1.24	-1.19
1 kHz 80% AM	1880	140.2	142	106.24	-121.8	-24.73
CW	1880					-25.94
				MIF (dB):	-1.218	-1.21

Notes:

•The output at the Fast Tap is a near-sinusoid corresponding to the square-law demodulated 1k 80% AM signal, with the average value given above calculated by the Oscilloscope.

•The output at the Slow Tap is a slow-averaged value of the signal presented by the Fast Tap. The value of this output should be very close to the result calculated by the oscilloscope for the signal output at the Fast Tap.

•The output at the Weighted Tap is a DC level proportional to the spectral and temporal filtered output of the demodulated input signal.

•The output at the MIF Tap is a DC level proportional to the ratio of the modulation's filtered audio characteristics to its slow-averaged signal level, as noted in the Tester Box's specification. The scale factor to find the measured MIF is 10 dB/volt.

•The difference in the average power of the modulated and unmodulated signal as measured by the Power Meter should, for this modulation, correspond to the MIF reported by the Tester Box.

MIF Measurements

The intent of these measurements is to use phone samples providing several modulations of interest to investigate each modulation type's potential MIF. The modulations investigated are GSM, CDMA (Full and 1/8th Rate), and WCDMA. In each case, the Phone sample is commanded by the Base Station to a known operating test configuration (the same as used for testing under C63.19-2007) and measured using the Tester Box and Power Meter/Sensor. These measurements are conducted per the following steps, as laid out by the proposed MIF measurement method:

- Connect the Base Station/Phone to the Power Meter/Sensor, and command the Phone to transmit. Adjust the Attenuator to the desired value for input to the Tester Box. Record the value on the Power Meter.
- Connect the Base Station/Phone to the Tester Box. Record the values at the four outputs of the Tester Box as measured by the Oscilloscope.
- Disconnect the Base Station/Phone, and connect the Signal Generator to the Tester Box. Command the Signal Generator to provide a 1 kHz 80% AM modulated signal at the same frequency as that provided by the Phone's signal.
- Adjust the AM signal level to provide the same output at the Weighted Tap of the Tester Box as that recorded in step 2.
- Connect the Signal Generator to the Power Meter/Sensor. Record the value on the Power Meter.
- Command the Signal Generator to remove the modulation from the carrier. Record the value on the Power Meter.

The expected results are as follows:

- An MIF measured by the Tester Box for each modulation type.
- An MIF calculated from the Power Meter measurements for each modulation type. This MIF is calculated as the difference in the average power between the modulated signal of interest and the unmodulated carrier.
- All MIF values for GSM to be near +3.3 dB as predicted by simulation of a 1/8th rate, 217 Hz square-wave pulse train.
- Agreement between the MIF measured by the Tester Box and that calculated from power measurements.

The phone samples used for these measurements are a Motorola V9x RAZR2 (FCC ID IHDT56JR1) for the GSM and WCDMA modulations, and a Motorola QA30 Hint (FCC ID IHDP56JX2) for the CDMA modulations.

MIF Measurements

GSM Measurements:

Phone or Signal Generator Mode	Frequency (MHz)	Attenuator Setting (dB)	Power Meter Avg PW (dBm)	Tester Box			
				Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)
GSM 850	848.8	-50	-31.6	46.6	46.2	67.08	181.4
1 kHz 80% AM			-26.71	90.8	90.5	67.18	-124.4
CW			-27.87				
MIF (dB):			3.73				1.814
GSM 850	848.8	-45	-26.52	111.2	118.4	214	297.6
1 kHz 80% AM			-21.73	285.6	290.8	213.7	-121
CW			-22.86				
MIF (dB):			3.66				2.976
GSM 850	848.8	-40	-21.52	332	336	690.4	345
1 kHz 80% AM			-16.62	920	913	690.6	-120.1
CW			-17.78				
MIF (dB):			3.74				3.45
GSM 850	848.8	-35	-16.4	628	648	1248.4	342.5
1 kHz 80% AM			-14.07	1686	1698	1248.8	-119.2
CW			-15.23				
MIF (dB):			1.17				3.425

MIF Measurements

Phone or Signal Generator Mode	Frequency (MHz)	Attenuator Setting (dB)	Power Meter Avg PW (dBm)	Tester Box			
				Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)
GSM 1900	1850.2	-50	-36.2	25.7	24.2	25.7	42.22
1 kHz 80% AM			-31.21	33.4	35	25.7	-126.72
CW			-32.35				
MIF (dB):			3.85				0.4222
GSM 1900	1850.2	-45	-31.1	52	51.6	80.48	236.4
1 kHz 80% AM			-25.98	106.8	109.4	80.48	-122.48
CW			-27.21				
MIF (dB):			3.89				2.364
GSM 1900	1850.2	-40	-26.1	122.4	126.4	257	326.4
1 kHz 80% AM			-20.94	338.4	341.2	257	-119.88
CW			-22.13				
MIF (dB):			3.97				3.264
GSM 1900	1850.2	-35	-20.94	367	373	848.8	377.6
1 kHz 80% AM			-15.85	1124	1114	850.6	-117.32
CW			-17.02				
MIF (dB):			3.92				3.776
GSM 1900	1850.2	-30	-15.92	614	594	1250.4	342.1
1 kHz 80% AM			-14.16	1686	1706	1254	-116.92
CW			-15.36				
MIF (dB):			0.56				3.421

MIF Measurements

Notes:

•The GSM measurements were conducted with a series of different power levels presented to the Tester Box, to survey the results across input signal levels.

•The MIF measured by the Tester Box is very sensitive to input power. Measurements with inputs near the edges of its operating range provide results very different from those predicted.

•The GSM signal provided by the Phone does not match the ideal pulse train of a 1/8th Duty Cycle, 217 Hz square wave. The Phone operating in its test configuration exhibits a pulse train with some pseudorandom behavior, missing some pulses and forcing others to peak higher than normal. This is assumed to be due to control signals in the communications link and is typical behavior for the Phone.

•The MIF values found for GSM through power measurements are higher than predicted by simulation. This is likely due to the behavior described above.

•There is little agreement between the MIF measured by the Tester Box and that calculated from power measurements.

MIF Measurements

WCDMA Measurements:

Phone or Signal Generator Mode	Frequency (MHz)	Attenuator Setting (dB)	Power Meter Avg PW (dBm)	Tester Box			
				Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)
WCDMA 850	846.6	-35	-16.03	1057	1061	9.95	-2030
1 kHz 80% AM			-34.84			10.02	
CW			-35.92				
MIF (dB):			-19.89				-20.3
WCDMA 1900	1852.4	-35	-16.92	870	871	7.75	-1970
1 kHz 80% AM			-36.18			7.712	
CW			-37.21				
MIF (dB):			-20.29				-19.7

Notes:

- The WCDMA signal presented by the measurement setup is nearly CW in nature, which presents some small amount of digital modulation “noise” on a DC carrier after demodulation by the square-law detector of the Tester Box.
- The MIF measured shows agreement between the Tester Box and that calculated from power measurements.

MIF Measurements

CDMA Measurements, Full Rate:

Phone or Signal Generator Mode	Frequency (MHz)	Attenuator Setting (dB)	Power Meter Avg PW (dBm)	Tester Box			
				Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)
CDMA 800 Full	836.52	-35	-15.24	1234	1280	13.74	-1968
1 kHz 80% AM			-33.48			13.74	
CW			-34.64				
MIF (dB):			-19.4				-19.68
CDMA 1900 Full	1908.75	-25	-18.31	651	655	7.76	-1930
1 kHz 80% AM			-36.25			7.76	
CW			-37.43				
MIF (dB):			-19.12				-19.3

Notes:

•The CDMA signal presented by the measurement setup is similarly CW in nature, which provides results similar to WCDMA.

•The MIF measured shows agreement between the Tester Box and that calculated from power measurements.

MIF Measurements

CDMA Measurements, 800 MHz 1/8th Rate:

Phone or Signal Generator Mode	Frequency (MHz)	Attenuator Setting (dB)	Power Meter Avg PW (dBm)	Tester Box			
				Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)
CDMA 800 8th	836.52	-40	-29.35	74	74.4	104.08	176
1 kHz 80% AM			-24.72	139.2	142	104.08	-124.04
CW			-25.9				
MIF (dB):			3.45				1.76
CDMA 800 8th	836.52	-35	-24.2	199.6	192.8	339.2	267.6
1 kHz 80% AM			-19.62	451.2	468	338.5	-122.44
CW			-20.77				
MIF (dB):			3.43				2.676
CDMA 800 8th	836.52	-31*	-20.2	488	486	870.8	308.5
1 kHz 80% AM			-15.6	1148	1146	869.2	-119.56
CW			-16.76				
MIF (dB):			3.44				3.085

Notes:

•The asterisked measurement was conducted with the Attenuator set to -31 dB, as attempts to use -30 dB resulted in Over voltage warnings when feeding the Tester Box with the modulated Phone signal.

MIF Measurements

CDMA Measurements, 1900 MHz 1/8th Rate:

Phone or Signal Generator Mode	Frequency (MHz)	Attenuator Setting (dB)	Power Meter Avg PW (dBm)	Tester Box			
				Fast Tap (mV avg)	Slow Tap (mV avg)	Weighted Tap (mV)	MIF Tap (mV)
CDMA 1900 8th	1908.75	-35	-26.29	125.6	132.4	214.9	248.2
1 kHz 80% AM			-21.85	285.2	290	214	-120.3
CW			-23.03				
MIF (dB):			3.26				2.482
CDMA 1900 8th	1908.75	-30	-20.95	385	388	730.4	297.6
1 kHz 80% AM			-16.54	973	973	731.8	-118.5
CW			-17.72				
MIF (dB):			3.23				2.976
CDMA 1900 8th	1908.75	-25	-16.2	650	690	1232	299.5
1 kHz 80% AM			-14.28	1644	1664	1230.4	-117.7
CW			-15.47				
MIF (dB):			0.73				2.995

MIF Measurements

Notes:

•The 1/8TH Rate CDMA measurements were conducted with a series of different power levels presented to the Tester Box, to survey the results across input signal levels.

•As with the GSM measurements, the MIF measured by the Tester Box is very sensitive to input power. Measurements with inputs near the edges of its operating range provide results very different from those predicted.

•The 1/8TH Rate CDMA signal provided by the Phone does not present an ideal pulse train. The Phone operating in its test configuration exhibits significant pseudorandom behavior, missing pulses regularly and forcing others to peak higher than normal. This is assumed to be due to control signals in the communications link and is typical behavior for the Phone.

•There is little agreement between the MIF measured by the Tester Box and that calculated from power measurements for the 1/8TH Rate CDMA signal.

Phone Performance Comparisons

The intent of the following presentation is to provide an overview of the results generated from the MIF measurements and their potential impact on product performance against the proposed standard.

When reviewing the tables to follow, the following points must be considered:

•For discussion's sake a single MIF is chosen for each modulation type, roughly averaged from the preceding measurements. These MIF values are:

- GSM: +3.8 dB
- WCDMA: -20 dB
- CDMA (Full Rate): -19.2 dB
- CDMA (1/8th Rate): +3.4 dB

•These MIF values are for the Phones operating in a specified test configuration as commanded by the Base Station, to a mode of operation suitable for testing to C63.19-2007. These modes of operation (and their modulation characteristics) *may not be suitable for test under the proposed methodology*, as they do not necessarily represent the "most interfering mode" experienced by a user under real-world conditions.

•All field measurement data was taken from the regulatory filing for each Phone noted. The values shown are the worst-case results for each transmit band reported.

Phone Performance Comparisons

Measurements and Calculations:

Phone Model, FCC ID	Band, Mode	Frequency (MHz)	Peak E-Field After Excl (V/m)	Peak E-Field After Excl (dB V/m)	PMF (linear)	PMF (dB)	Total Peak (dB V/m)	AWF	2007 M3 Limit (dB V/m)	Margin to M3 Limit (dB)	M-Rating (2007)
			Peak E-Field After Excl (V/m)	Peak E-Field After Excl (dB V/m)		MIF (dB)	Total Peak (dB V/m)		Draft 1.9 M3 Limit (dB V/m)	Margin to M3 Limit (dB)	M-Rating (Draft 1.9)
V9x IHDT56JR1	GSM 850	848.8	55.6	34.90	2.85	9.10	44.00	-5	48.5	4.5	M3
			55.6	34.90		3.80	38.70		45.0	6.3	M4
	GSM 1900	1850.2	26.7	28.53	2.87	9.16	37.69	-5	38.5	0.8	M3
			26.7	28.53		3.80	32.33		35.0	2.7	M3
	WCDMA 850	846.6	50.5	34.07	0.92	-0.72	33.34	0	51.0	17.7	M4
			50.5	34.07		-20.00	14.07		45.0	30.93	M4
	WCDMA 1900	1852.4	43.4	32.75	0.92	-0.72	32.03	0	41.0	9.0	M4
			43.4	32.75		-20.00	12.75		35.0	22.25	M4
QA30, IHDP56JX2	CDMA 800 Full Rate	836.52	107.2	40.60	1.03	0.26	40.86	0	51.0	10.1	M4
			107.2	40.60		-19.20	21.40		45.0	23.60	M4
	CDMA 800 1/8th Rate	836.52	37.7	31.53	2.78	8.88	40.41	0	51.0	10.6	M4
			37.7	31.53		3.40	34.93		45.0	10.07	M4
	CDMA 1900 Full Rate	1908.75	43.3	32.73	1.07	0.59	33.32	0	41.0	7.7	M4
			43.3	32.73		-19.20	13.53		35.0	21.47	M4
	CDMA 1900 1/8th Rate	1908.75	15.4	23.75	2.89	9.22	32.97	0	41.0	8.0	M4
			15.4	23.75		3.40	27.15		35.0	7.85	M4

References

•Julstrom, Steve; “RF Audio Interference Level Test Interface V1.0 Quick Users Guide”

Revision History

March 10, 2009 – Initial release