Application Note 54

Interpreting CDMA Mobile Phone Testing Requirements

Most people who are not intimately familiar with the protocol involved with IS-95A & J-STD-008 (CDMA) phones will encounter some confusion when interpreting the minimum performance standards of IS-98A/J-STD-018 for the first time. In order to conduct testing, CDMA technology, test standards, and test instrumentation must be understood. The purpose of this application note is to facilitate understanding of CDMA test parameters and how to apply these parameters to a specific test setup in order to execute IS-98A compliant tests.

Test Setup

Although IS-98A requires multiple test setups, the most typical test setup is shown Figure 1. In this configuration, a base station emulator, an RF channel emulator, a C/N emulator, and a mobile phone are required.

This test setup can be easily recognized by using commercially available test equipment (See Figure 2). In this example, we will use a base station emulator, a TAS 4500 RF Channel Emulator, a TAS 4600 Noise and Interference Emulator, and a dual junction circulator for interfacing to the mobile phone's duplex port. For more information on the circulator, please refer to the "Notes on Testing" section.

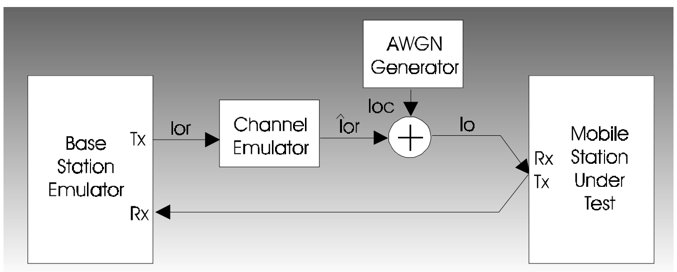

Figure 1. Example of Functional Test Setup from IS-98A

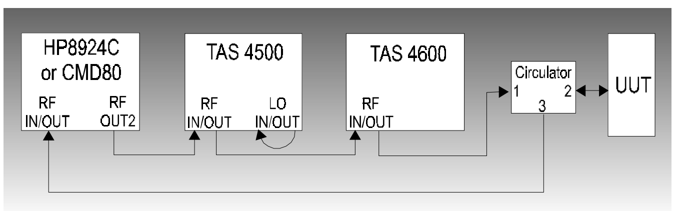

Figure 2. Test Setup for IS-98A Compliance Testing

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Description of Test Parameters

An example set of test conditions that will be used throughout this document is shown in Table 1. The information in this table is taken directly out of IS-98A, section 9.3.3 titled "Demodulation of Forward Traffic Channel in Additive White Gaussian Noise"

In order to begin testing, the parameters in Table 1 must be understood. Unfortunately, the parameters in this table do not give all the information to necessary to configure your test setup. By using these values and some basic CDMA concepts, the other necessary parameters can be derived. The next section will give a description of the test parameters. In addition, the parameters that are implied in this table will be explained.

Parameter	Units	Test 7	Test 8	Test 9
I_{or}/I_{oc}	dB	4		
Pilot E_c/I_{or}	dB	-7		
Traffic E_c/I_{or}	dB	-14.4	-17.5	-21.3
I_{oc}	dBm/1.23 MHz	-59		
Data Rate	bps	4800	2400	1200
Traffic E_b/N_t	dB	13.7	13.6	12.8
Channel Simulator Configuration		3		

Table 1. Demodulation of Forward Traffic Channel in AWGN Tests

NOTE: The Traffic Eb/Nt value is calculated from the parameters in the table. It is not an adjustable parameter.

I_{oc}

The power spectral density of a band limited white noise source (simulating interference from other cells) as measured at the mobile station antenna connector. IS-98A specifies that the noise source used must have a noise bandwidth greater than 1.8 MHz. It is important that the noise source be sufficiently wide to simulate interference from other cells. An even wider noise source (>10 MHz) will have the added benefit of testing the receiver's ability to reject broadband noise. A 5 MHz plot of the TAS 4600 noise source is shown in Figure 3.

The I_{oc} parameter, along with the I_{or}/I_{oc} (signal-to-noise) value defines the channel power, and the carrier-to-noise ratio parameters to be set in the TAS 4600 Noise and Interference Emulator.

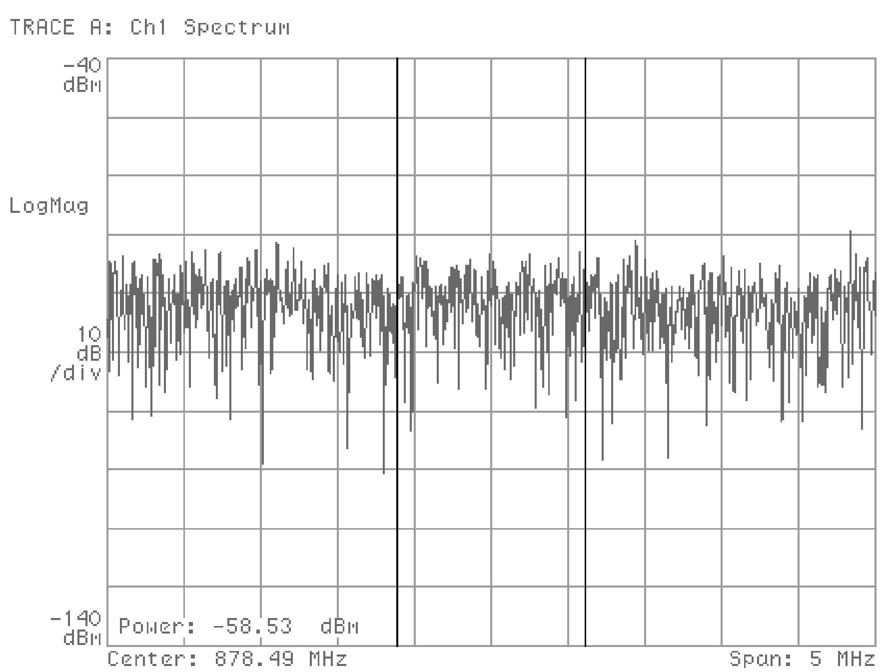

Figure 3. Spectrum of TAS 4600 Broadband Noise Source

Description of Test Parameters - *Continued*

I_{or} / I_{oc}

The forward channel signal-to-noise ratio for a 1.23 MHz bandwidth. This parameter is set in the 4600 with the C/N parameter. Since a CDMA signal is noise like, and since CDMA is designed to operate at a low signal-to-noise ratio, it is difficult to view the CDMA carrier signal with additive noise present on a spectrum analyzer. Figure 4 shows two plots of an impaired CDMA channel at a 4 dB signal-to-noise ratio. The first plot uses the default analyzer settings. It is obvious that the CDMA channel is indeed difficult to find. The second plot in Figure 4 shows the same signal on an expanded scale with 16 times video averaging.

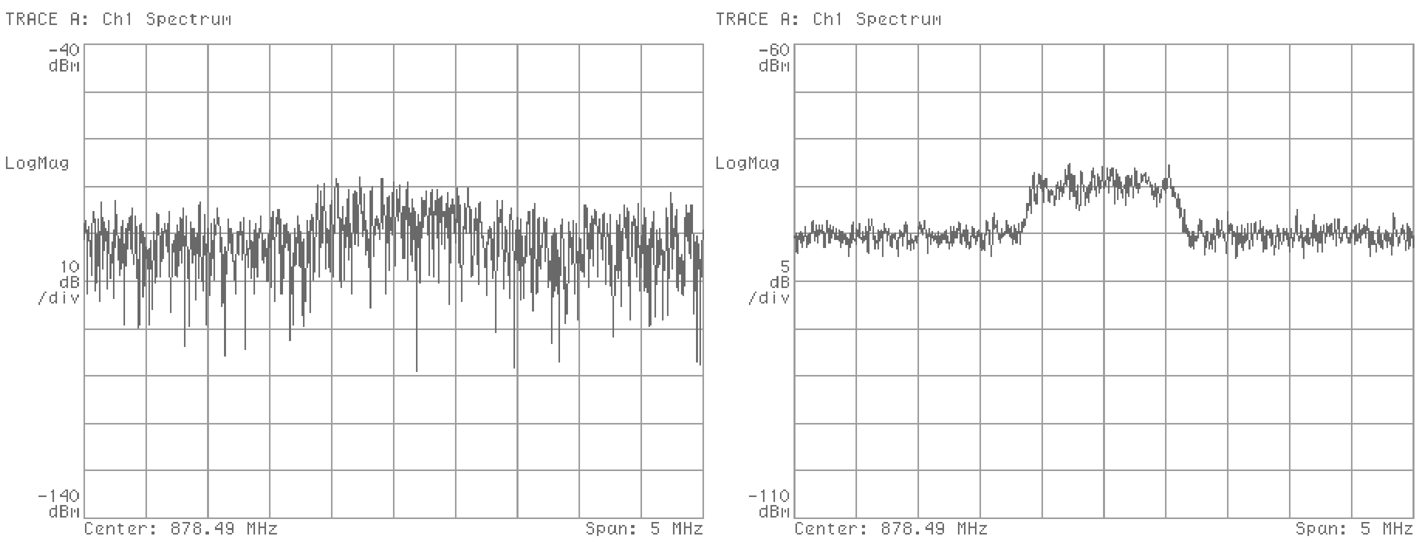

Figure 4. CDMA Channel with Broadband Noise (4dB Signal-to-Noise Ratio)

Pilot E_c / I_{or}

The fraction of the total base station transmitted power dedicated to the pilot channel. This level will be set directly in the base station emulator. In the example listed in Table 1, the pilot level would be set to -7 dB. This level tells the base station emulator to dedicate 1/5 of the total transmit power (I_{or}) to the pilot channel.

In IS-98A the levels of the various components of the total transmit power are specified as the fraction of the total transmit power. The sum of these fractional parts should add up to 1. Section 1.6.1 of IS-98A uses the following Equation # 1 to relate the various levels of the total base station transmit power.

Equation # 1:

$$\frac{\text{Pilot } E_c}{I_{or}} + \frac{\text{Sync } E_c}{I_{or}} + \frac{\text{Paging } E_c}{I_{or}} + \frac{\text{Traffic } E_c}{I_{or}} + \frac{\text{Power Control } E_c}{I_{or}} + \frac{\text{OCNS } E_c}{I_{or}} = 1$$

Description of Test Parameters *- Continued*

Traffic E_c / I_{or}

The fraction of the total base station transmitted power dedicated to the forward traffic channel. This level will also be set in the base station emulator. In some base station emulators, the traffic level that is set refers to full rate traffic only, where full rate is 9600 bps for rate set 1, and 14400 bps for rate set 2. Thus, a correction is needed when using data rates that are not full rate. For example, in test 9 above, the data rate is 1200 bps, or eighth rate. In this case the traffic level that would be set in the base station emulator is shown in Equation #2.

Equation # 2: $$\frac{\text{Traffic } E_c}{I_{or}} - 10\log_{10}(\text{fractional rate}) \quad = -21.3 - (-9) \quad = -12.3\,\text{dB}$$

Data Rate

The number of bits per second of information being transmitted on the forward traffic channel. This value is set in the base station emulator. Typically, the rate set and the fractional rate is programmed into the base station emulator. Rate set 1's full rate is 9600 bps, while rate set 2's full rate is 14400 bps. 4800, 2400, and 1200 bps correspond to 1/2, 1/4, and 1/8 rate on rate set 1, while 7200, 3600, and 1800 bps correspond to 1/2, 1/4, and 1/8 rate on rate set 2. The data rate affects the calculation of Traffic Eb/Nt, and can also affect the traffic level programmed into the base station emulator (see Traffic E_c/I_{or} above)

Equation # 3: $$\text{Traffic } E_b / N_t = \left(\frac{I_{or}}{I_{oc}}\right) + \left(\frac{\text{Traffic } E_c}{I_{or}}\right) + 10\log_{10}\left(\frac{1228800}{\text{data rate}}\right)$$

Traffic E_b / N_t

The effective bit energy to noise density of the forward traffic channel. As Table 1 shows, this number is not a settable parameter, but is in fact a function of the other parameters in the table. This number can be calculated using Equation #3. For example, in test 7 listed in Table 1, the Traffic E_b/N_t would be calculated as shown in Equation #4. Equation #3 for Traffic E_b/N_t is valid only for the case of one path channel simulator configurations. Calculation of the Traffic E_b/N_t for 2 and 3 paths for the channel configurations given in IS-98A can be calculated using the formulas in section 1.6.2 of IS-98A.

Equation # 4: $$\text{Traffic } E_b/N_t = (4) + (-14.4) + 10\log_{10}(256) = 13.68 \text{ » } 13.7\text{ dB}$$

Channel Configuration

One of five standard configurations shown in Table 2 (from IS-98A). This information is programmed into the TAS 4500 RF Channel Emulator.

Channel Emulator Configuration	1	2	3	4	5
Vehicle Speed [km/hr]	8	30	30	100	0
Number of Paths	2	2	1	3	2
Path 2 Power (Relative to Path 1) [dB]	0	0	N/A	0	0
Path 3 Power (Relative to Path 1) [dB]	N/A	N/A	N/A	-3	N/A
Delay from Path 1 to Input (us)	0	0	0	0	0
Delay from Path 2 to Input (us)	2	2	N/A	2	2
Delay from Path 3 to Input (us)	N/A	N/A	N/A	14.5	N/A

Description of Implied Parameters

I_{or}

This is the total transmit power spectral density of the forward channel. This value is not explicitly stated in the test tables, but can be derived from other information in table. For example, in the tests listed in Table 1, the signal-to-noise ratio (I_{or}/I_{oc}) is given as 4 dB, and the received power spectral density of the bandlimited white noise is given as -59 dBm/ 1.23 MHz. Thus, Ior would be calculated as shown in Equation #5. This value for the total transmit power is then programmed into the TAS 4600 Noise and Interference Emulator as the carrier power level.

Equation # 5:

$$I_{or} = I_{or}/I_{oc} + I_{oc} = (-59) + (4) = -55 \text{ dBm}$$

Paging E_c / I_{or}

The paging channel makes up a portion of the total forward transmit power. The paging channel carries various control and page messages from the base station to the mobile station. Although not stated explicitly for each test, the paging level should be set to -12 dB (1/25) of the total transmit power unless otherwise specified.

Sync E_c / I_{or}

The sync channel carries the synchronization message to the mobile station on a dedicated channel. Although not stated explicitly for each test, the paging level should be set to -16 dB (1/40) of the total transmit power unless otherwise specified.

Power Control E_c / I_{or}

The closed loop power control bits are sent on the forward traffic channel. Forward traffic channel bits are punctured (removed) and replaced by power control bits every 1.25 ms. This is not a settable parameter in the base station emulator. However, its value can be calculated from equations in section 1.6.1 of IS-98A.

OCNS E_c / I_{or}

The OCNS is the Orthogonal Channel Noise Simulator, a hardware mechanism used to simulate users on other orthogonal channels of the forward CDMA channel. The OCNS makes up the remainder of the total transmit power, and is typically automatically set as such in the base station emulator.

Notes on Testing

The pilot level and the data rate can be directly programmed into the base station emulator. The traffic level entered into the base station emulator, should have appropriate compensation for the fact that the traffic level is based on full rate transmission. Thus, 3, 6, or 9 dB should be added to the traffic level listed in the table for 1/2, 1/4 and 1/8 rates respectively.

Since the base station emulator is not connected directly to the device under test, it is important to carefully consider its output power. In the case of the test setup shown in Figure 2, a nominal output power of -10 dBm would satisfy the input requirements of the TAS 4500 RF Channel Emulator. The absolute power level, Ior, would be set later in the test channel by the TAS 4600 Noise and Interference Emulator, because using the TAS 4600 to set the forward channel power will provide the best accuracy.

The carrier frequency entered into the TAS 4500 RF Channel Emulator and the TAS 4600 Noise and Interference Emulator can be calculated from the channel number, N, using Equation #6.

In the block diagram of the test setup in Figure 2, a Ma-Com 7R193 dual junction circulator is used to interface to the duplex port on the mobile phone. The high isolation junction of the dual junction circulator should be used between the phone and TAS 4600. A high powered signal leaking back into the TAS 4600 could result in intermodulation products. The high isolation of the dual junction circulator will insure that very little mobile transmit power leaks back into the noise and interference emulator.

This sections summarizes the configuration for the TAS 4500 and the TAS 4600. In Table 3 & 4, the configuration and parameters of both instruments are provided.

Equation # 6:

$$\text{Center Frequency} = \begin{cases} 0.030N + 870.000 \quad \text{MHz} & 1 \le N \le 799 \\ 0.030(N - 1023) + 870.000 \quad \text{MHz} & 990 \le N \le 1023 \end{cases}$$

Summary of Parameter Setup for TAS 4500 and Tas 4600

Table 3. TAS 4500 Parameter Configuration

TAS 4500 Configuration						
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope					
Channel	**1**					
Input Reference Level	-10.0 dBm					
Output Attenuator	0 dBm					
LO Mode	internal auto					
Carrier Freq. (MHz)	878.49					
Path	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	off	off	off	off	off
Relative Delay (us)	0.0	-	-	-	-	-
Modulation Type	Rayl.	-	-	-	-	-
Doppler Freq. (Hz)	24.4	-	-	-	-	-
Velocity (km/h)	30	-	-	-	-	-
Fading Power Spectrum	C6	-	-	-	-	-
Relative Loss (dB)	0	-	-	-	-	-
Log-normal Freq. (Hz)	0	-	-	-	-	-
Log-normal STD (dB)	0	-	-	-	-	-

Table 4. TAS 4600 Parameter Configuration

TAS 4600 Configuration		
Carrier to Noise Units	C/N	
Noise Generator Units	-	
Interference Source A Status	off	
Interference Source B Status	off	
Impairments CH1	off	
Impairments CH2	-	
Channel	**1**	**2**
Carrier Freq. (MHz)	878.5	-
Emulation Mode	C/N	-
Receiver Bandwidth (MHz)	1.23	-
Carrier to Noise Ratio (dB)	4.0	-
Bit Rate (bps)	-	-
E_b/N_0 Ratio (dB)	-	-
C/N_0 (dB)	-	-
C/I (dB)	-	-
Noise Power Density (dBm)	-	-
Output Level (dBm)	-55.0	-
Measure		
Monitor Point	CH1	
# Averages	$16(2^4)$	
Duty Cycle	100%	

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