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# CDMA Source Generation Effects for ACPR/ACI Simulation

## Technical Note

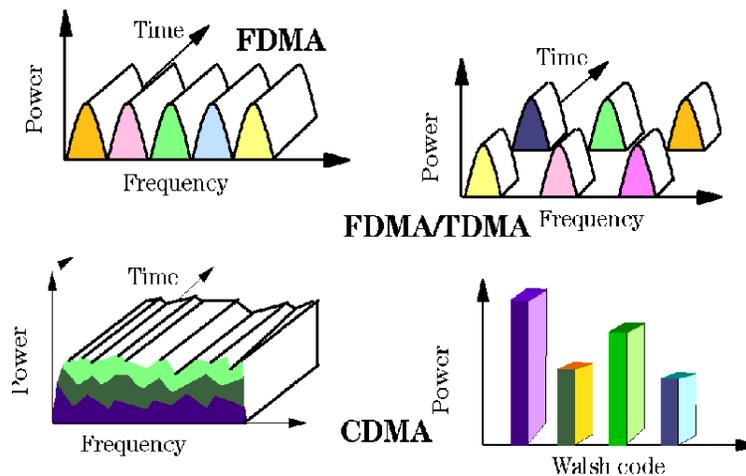
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### Introduction

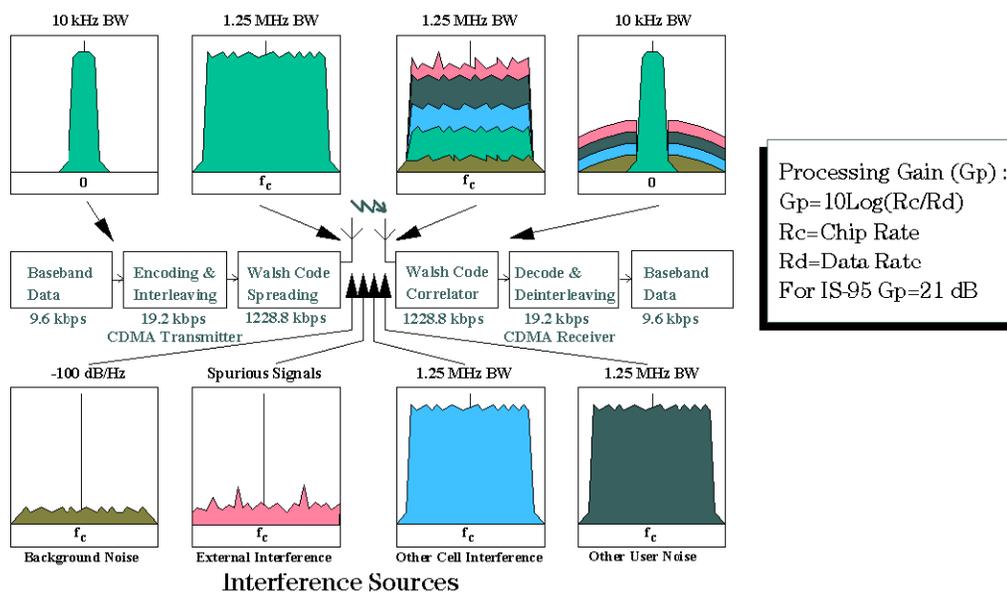
Adjacent Channel Power Ratio (ACPR) and Adjacent Channel Interference (ACI) simulations and measurements are among the most critical performance parameters for communications systems because of the potential for a transmitted signal to disrupt other communication signals. It is important to be able to predict when a base or mobile transmitter will broadcast significant RF power outside of its allotted RF channel and thus interfere with adjacent channels. Proper simulation of ACPR/ACI requires that a test signal be generated which has the correct peak-to-average power ratio or crest factor. In the CDMA (Code Division Multiple Access) situation, the peak-to-average ratio varies with the particular traffic channels that are active at a given time, as determined by the associated Walsh functions used to insert those traffic channels into the channel carrier. Thus, proper ACPR/ACI simulation requires user selection of specific traffic channels. This Product Note describes a simulation in HP EEsof Advanced Design System (ADS) which facilitates CDMA ACPR/ACI investigations for various power amplifier scenarios.

## The CDMA System

The CDMA System is based upon a multiple access technique using orthogonal codes to keep various information channels separate from each other. Other methods in use include FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access) and FDMA/TDMA used together. The CDMA approach utilizes a family of orthogonal codes known as Walsh functions. When digitized speech information is combined with such a code and then modulated onto a carrier along with other coded speech signals having different Walsh codes, the data do not interfere with each other due to the orthogonal properties of Walsh codes. (Figures 1 and 2)

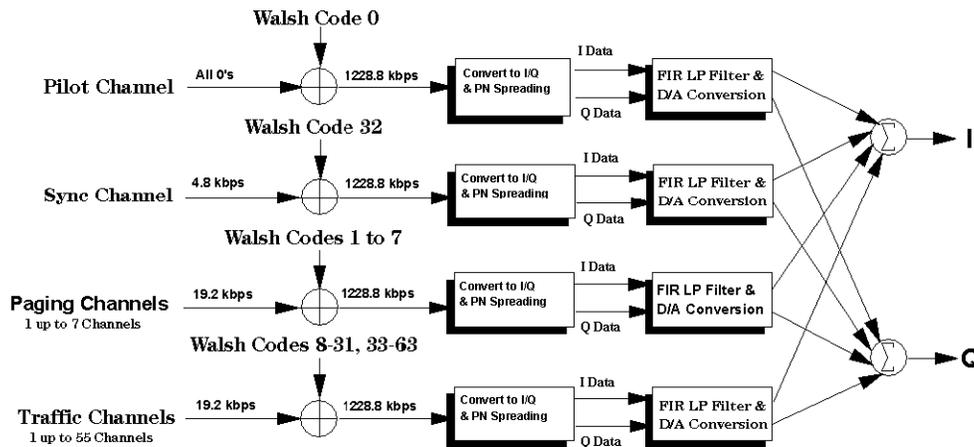


**Figure 1. Cellular access methods**



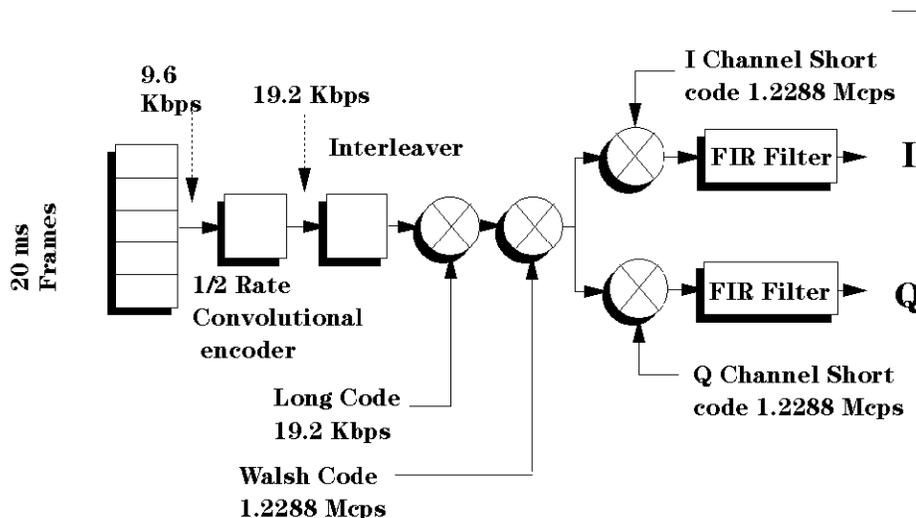
**Figure 2. The CDMA concept**

A channel spacing of 1.25 MHz is used. The IS-95 system utilizes a set of 64 Walsh codes. Some channels are reserved for pilot, synch and paging usage; the remainder are available for traffic. The IS-97 specification defines a test signal consisting of 9 total channels, including pilot, synch, paging and 6 traffic channels. (Figure 3)



**Figure 3. Implementation of Walsh codes**

The IS-95 Forward (Base Station) link is illustrated in Figure 4. QPSK modulation is used, and there is a slow “long” code, plus the Walsh code and PN codes, which are at the chip rate of 1.2288 Mbps. For ACPR/ACI simulation purposes, we can ignore the data manipulation up to the Walsh coding and simply substitute pseudo-random data at the appropriate rate. The signal envelope changes that determine the peak-to-average power ratio of the signal are mainly due to the Walsh functions and to a lesser extent, the PN codes.



**Figure 4. IS-95 CDMA Forward link**

## The ADS Implementation

An ADS implementation of this modulator is available in the example IS95\_prj, found in the /Com\_Sys example sub-directory. To view this example, select File > Example Project from the Main window of ADS, moving into the Com\_Sys sub-directory. On Unix systems, it is necessary to copy the example project to your local working directory in order to allow simulations. This may be accomplished using File > Copy Project from the Main window. When you open the project by double-clicking on the name, IS95\_prj, several windows will open, each containing a schematic design. On some workstations, the windows may need to be moved up and to the left in order to be visible. There are 3 designs shown in these windows:

**IS97\_9Channel\_TestGen:** This is the top-level design for generating the 9-channel signal that we wish to use for ACPR/ACI simulations.

**IS95\_fwd\_mod\_block:** This is one of 9 modulator blocks that are used as sub-networks to IS97\_9Channel\_TestGen. Specific Walsh code and output power data are passed into the sub-networks using parameters created for that network.

**IS95\_forward\_modulator:** This is a standalone design which creates a single traffic channel CDMA signal, and contains all measurement items to show the output spectra and intermediate signals.

Within the IS97\_9Channel\_TestGen design, there is a variable block, which sets the specific Walsh codes to be assigned to the 6 traffic channels (Figure 5).

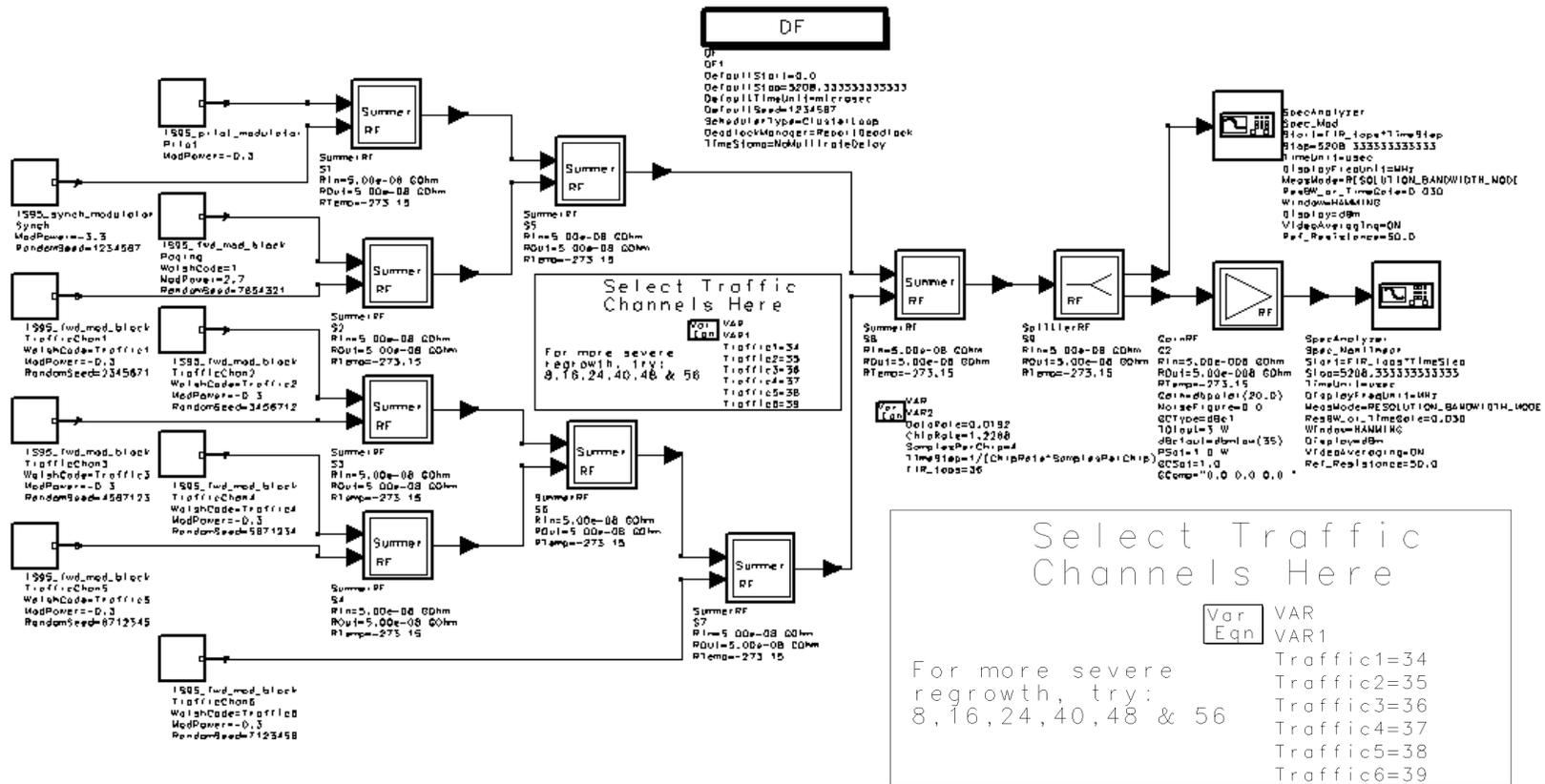


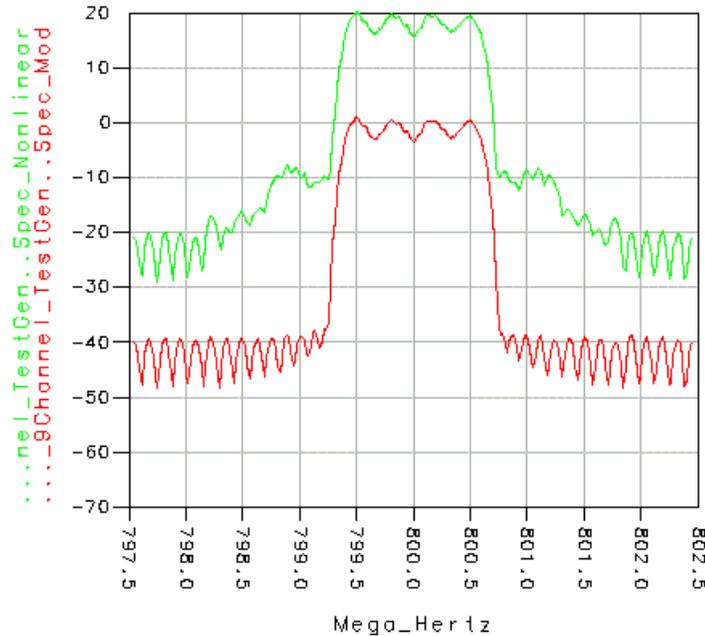
Figure 5. ADS implementation of 9 channel modulator with detail showing settings of specific traffic channels

The following table indicates the channel designations, Walsh codes and relative power levels amongst all 9 channels, per the IS97 specification:

<b>Channel</b>	<b>Code Channel</b>	<b>Linear Power</b>	<b>Power, dB</b>	<b>Symbol Rate</b>
Pilot	00	0.2000	-7.0	None
Sync	32	0.0471	-13.3	4.8 ksps
Paging	01-07	0.1882	-7.3	19.2 ksps
Traffic 1	8-31,33-63	0.0941	-10.3	19.2 ksps
Traffic 2	8-31,33-63	0.0941	-10.3	19.2 ksps
Traffic 3	8-31,33-63	0.0941	-10.3	19.2 ksps
Traffic 4	8-31,33-63	0.0941	-10.3	19.2 ksps
Traffic 5	8-31,33-63	0.0941	-10.3	19.2 ksps
Traffic 6	8-31,33-63	0.0941	-10.3	19.2 ksps

Some common Walsh code combinations have been identified as having a pronounced influence upon ACPR/ACI performance. The 6 channels using codes 8,16,24,40,48 and 56, for example, will typically produce 8-10 dB worse ACP at a 1.25 MHz offset than the combination 34,35,36,37,38 and 39. Note that the combination of the Walsh code with the data is performed by an exclusive-or “multiplication”, and therefore the output stream may be an inverted or non-inverted repeated copy of the Walsh code. In other words, a distinctive characteristic of the Walsh code is carried through this process and ultimately affects the peak-to-average amplitude characteristic of the modulated signal.

Figure 6 shows the resulting spectra for the case of codes 8,16,24,40,48 and 56. Each simulation run takes about 10 minutes using an HP C180 workstation. Data markers may be used on the Data Display page to perform accurate ACP measurements; the “delta mode” is recommended for this purpose. Once a particular amplifier model is specified, alternate channel codes may be specified by editing the VAR item on the schematic.



**Figure 6. Output spectra for ideal modulator and output of nonlinear amplifier using traffic channels 8,16, 24, 40, 48 and 56**

Another option in ADS is co-simulation with the Circuit Envelope simulator. The Circuit Envelope simulator allows for simulation of an arbitrary modulated signal with a detailed circuit-level model, as opposed to a behavioral model such as used in this example. In many situations, this can provide the most accurate simulation of ACP/ACI performance possible, since true non-linear and dynamic circuit behaviors, e.g. signal modulation of bias, are inherently included. Once a suitable circuit model is obtained, it may be inserted into the schematic in place of the HP Ptolemy behavioral model used here. It is also necessary to place an EnvOutShort component, which selects the desired frequency to be considered the carrier, and also provides a through path for the loading of the measurement or following component to be seen by the amplifier circuit. For the most efficient simulation, the time step in the Circuit Envelope controller that is placed on the circuit page should be set equal to the time step used in the top-level HP Ptolemy simulation. Note that Circuit Envelope co-simulation may take longer than when using only HP Ptolemy; the difference depends in part upon the complexity of the circuit being co-simulated.

### Summary

An ADS simulation for the determination of ACP/ACI performance with CDMA modulation has been presented. This simulation may be easily modified by the user to accommodate various combinations of coded traffic channels, which may significantly influence the level of adjacent channel power generation. The simulation example is included with ADS 1.01



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Printed in USA PN E4600-6 9/95

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