Correlation between P_{1dB} and ACP in TDMA Power Amplifiers

The ability to predict Adjacent Channel Power (ACP) performance from a simpler measurement simplifies amplifier development and testing

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The intention of these engineering notes is to obtain the correlation values between CW and TDMA (IS-136) linearity parameters of power amplifiers for wireless phones. The need to know that correlation is obtain better amplifier acceptance criteria.

The linearity of power amplifiers is characterized differently depending on the nature of the input signal. In the continuous wave (CW) mode (when an input signal is sinusoidal) the measure of linearity is an intercept point or, interchangeably, a 1 dB compression point. At the same time, the power amplifier for TDMA wireless phones has to be just linear enough to meet the adjacent and alternate channel power (ACP) specifications.

There are several reasons why we want to correlate both CW and TDMA linearity. Usually, the manufacturers of power amplifiers (or their components) prefer to characterize their products in CW terms. Even when the unit is characterized in TDMA terms, it is still beneficial to know the correlation between measures of linearity. This knowledge will help to confirm that the amplifier is optimally biased. It will also give the flexibility to bias the unit differently (for example, to improve efficiency).

In order to determine the desired correlation, we can simulate the application of a TDMA (IS-136) signal to the input of a power amplifier described in terms of CW linearity parameters. We then observe the ACP of the resulting output signal and obtain a correlation between CW and TDMA linearity parameters. Then we justify the obtained result by providing an appropriate theoretical explanation. It allows us to predict a dependence of ACP on any given value of 1 dB compression. Finally, to prove the validity of the results, we will compare the simulated results with experimental ones.

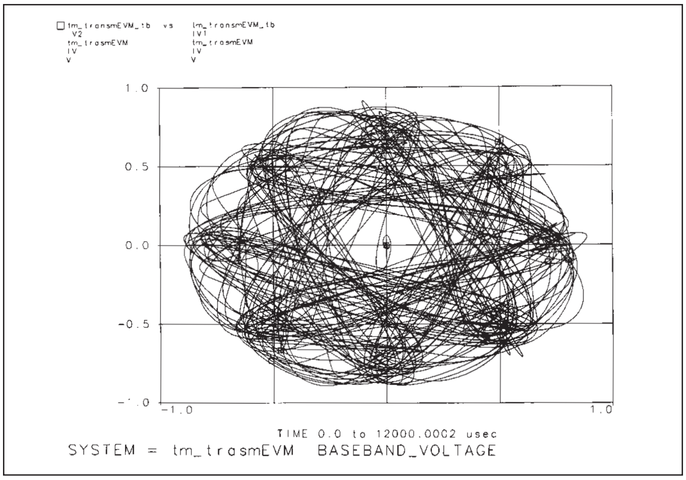
The software we use for simulation is a system evaluation tool from HP EEsof, OMNISYS. In order to conduct the simulation we generate a TDMA signal according to the requirements of IS-136 standard. Then we compose the schematic, determine the type of measurements required to achieve our goal, and obtain the measuring results.

Generation of TDMA signal

At first I and Q baseband signals are generated. There is a functional model in OMNISYS that generates a random binary data stream. It is called "DATA." We use two of these generators for the I and Q bit streams, each with random properties and with a large number of bits (212 and 214). We choose a different number of bits for I and Q to ensure a random character of the resulting signal. The length of each generated bit was chosen to be equal to the symbol length of IS-136 burst format, that is 41.152263 msec. To synchronize both generators (in order to provide truly I and Q signals) the OMNISYS functional model is used called "TimeControl."

Then generated I and Q signals are applied to the encoder. Its function is to impose a modulation format on unmodulated I and Q signals. There is a functional model in OMNISYS that differentially encodes data according to the chosen modulation format. It is called "IQ Data Encoder." The choice of the modulation format in that functional model is made to comply with the IS136 requirements, π/4DQPSK.

Then the encoded signals are applied to their respective Root Raised Cosine filters. Their function is to create raised cosine pulses, as



▲ **Figure 1. Encoded I versus Q constellation diagram.**

required by π/4DQPSK modulation format. The bandwidth of the filters should be equal to the reverse value of a double symbol duration. In that case, no inter-symbol interference results between them. The rolloff value of the filters is given in IS-136, and is equal to 0.35. If the encoding and filtering of the binary data stream signals are done correctly, then the resulting vectors should create a π/4DQPSK constellation diagram. The diagram is shown on Figure 1, as I_{enc} *vs*. Q_{enc}, that represents encoded voltages of I and Q data streams, respectively.

The resulting signals are applied to the quadrature amplitude modulator. Its function is to combine I and Q encoded signals and to up-convert them to IF frequency. It is done according to the formula:

$$V_{mod}(t) = A\,[I_{enc}(t)\cos(\omega ct) - Q_{enc}(t)\sin(\omega ct)] \qquad (1)$$

The functional model in OMNISYS that performs signal processing according to the formula (1) is called, as expected, "Quadrature Amplitude Modulator." All the inputs as well as the output of this model have 50 ohm impedances. Its output signal is characterized by the sinusoidal (CW) power and frequency. We choose the frequency to be 1890 MHz (to represent one of the channels of a PCS frequency band) and the power level of –12.5 dBm (unmodulated power level). With this power level the RF average modulated power at the output of the power amplifier is equal to 30.5 dBm. This value of the output power is exactly the same as the value of the power amplifier 1 dB compression point.

The obtained signal is applied to the preamplifier. It must present a realistic signal to the input of the power amplifier, that is, a signal with ACP of about 35 - 36 dB. This is achieved by varying the value of the preamplifier's 1 dB compression.

The signal described above is applied to the input of the power amplifier. Then the output signal of that aower amplifier is evaluated and the comparison between values of ACP and 1 dB compression is made based on the results of evaluation.

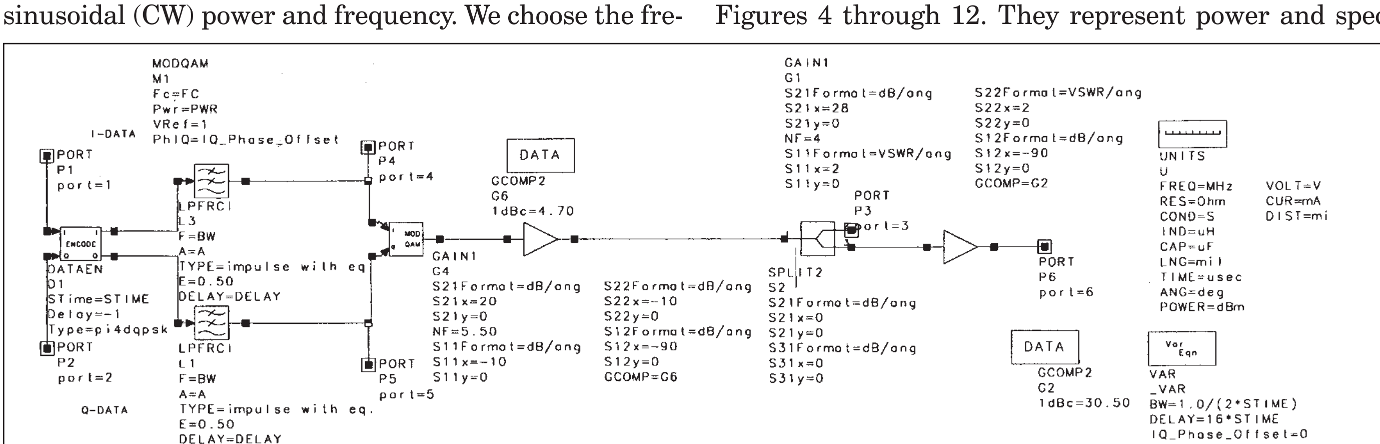
The functional block diagram used for simulation is given in Figure 2. The modulated signal from the output of modulator (MODQAM, M1) is applied to the preamplifier (GAIN1, G4) with output 1 dB compression point GCOMP2, G6. This signal is applied to the input of the power amplifier (GAIN1, G1) with output 1 dB compression point GCOMP2, G2. The input signal of the power amplifier is measured at PORT, P3. The output signal of the power amplifier is measured at PORT, P6.

Types of measurements

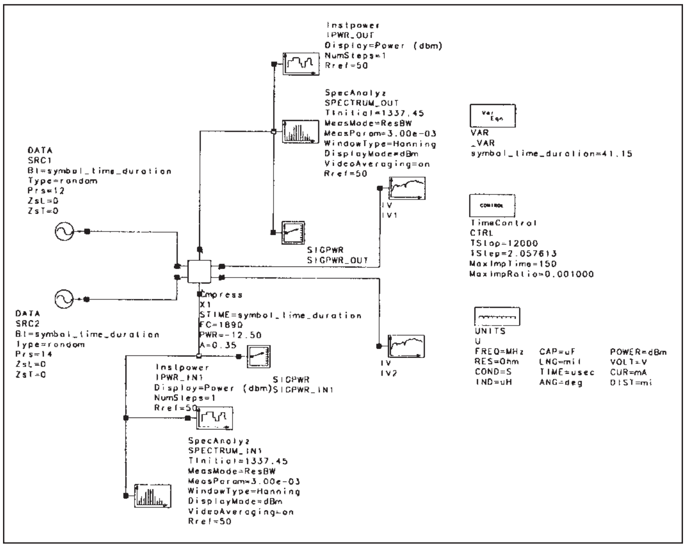
Our goal is to find a comparison between ACP and 1 dB compression. This goal determines the set of required measurements. The results we are looking for are the values of ACP as a function of an output power level. ACP itself is found from the spectral characteristics of the output signal. That is why we are interested in measurements of the values of average power and spectrum. The types of conducted measurements are given in Figure 3.

Simulation results

The simulated measurement results are given in Figures 4 through 12. They represent power and spec-



▲ **Figure 2. Functional block diagram of the simulation setup.**



▲ **Figure 3. Diagram of the simulated measurement types.**

trum measurements at the input and the output of the power amplifier. The power measurements are used for setting the output power level of the power amplifier to the level of the compression point, 3 dB below the compression point and 1 dB above the compression point. The spectrum measurements made at each of these power levels are used for the determination of ACP. The value of ACP is determined according to the method specified by IS-137.

Figures 4 - 6 show the ACP values with the output power level equal to the compression point. The measurement results of the power amplifier's input and output average power are given in Figure 4. These are straightforward results equivalent to actual measurements by an averaging power meter (like HP 437A). The output power is set to 30.5 dBm, that is it exactly coincides with the value of 1 dB compression of the power amplifier. The input power is equal to 3.8 dBm. So the actual gain of the power amplifier is less than 27 dB for the given small signal gain of 28 dB. It is an indication of a heavier compression of the power amplifier by a TDMA modulated signal than by a CW signal. The preamplifier compression point is equal to 4.4 dBm.

The simulation results of an input signal spectrum are given on Figure 5. It is a simulated result equivalent to actual measurements by a spectrum analyzer (like the HP 8561E).

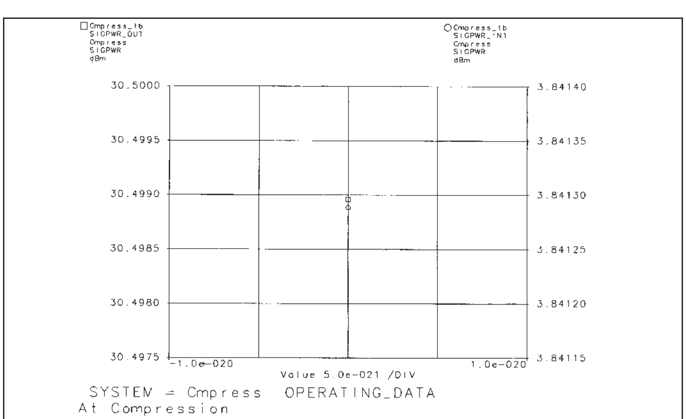
There is a provision in IS-137 regulating a clarity of the spectrum of modulated signals. It specifies the method of measurement and provides the limits for spectrum spreading in terms of ACP. The description of it is quoted here, "Using a spectrum analyzer or measuring receiver tuned to the transmitter nominal carrier frequency, obtain the mean output power as a reference." The limitations are to be as follows:

The emission power in either adjacent channel, centered +30 kHz from the center frequency, shall not exceed a level of 26 dB below the mean output power. The emission power in either alternate channel, centered +60 kHz from the center frequency, shall not exceed a level of 45 dB below the mean output power. The emission power in either second alternate channel centered +90 kHz from the center frequency, shall not exceed a level of 45 dB below the mean output power or –13 dBm, whichever is the lower power

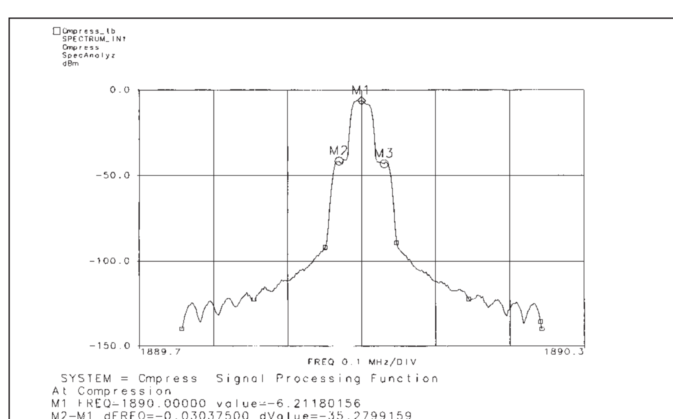
The spectrum analyzer's feature called "marker delta" makes it easy to perform described calculations of ACP. Using that feature in simulations confirms that the preamplifier with P_{1dB} = 4.4 dBm provides the desired input ACP value of about 35 - 36 dB (Figure 6).

The simulated results of an output signal spectrum are given in Figure 6. They are obtained in the same manner as results given in Figure 5, with the addition of relative power levels of alternate channels. The results show that when the value of TDMA modulated output power coincides with the 1 dB compression value, the ACP is ~28 dB. That is, the spec for ACP is met with a comfortable margin.

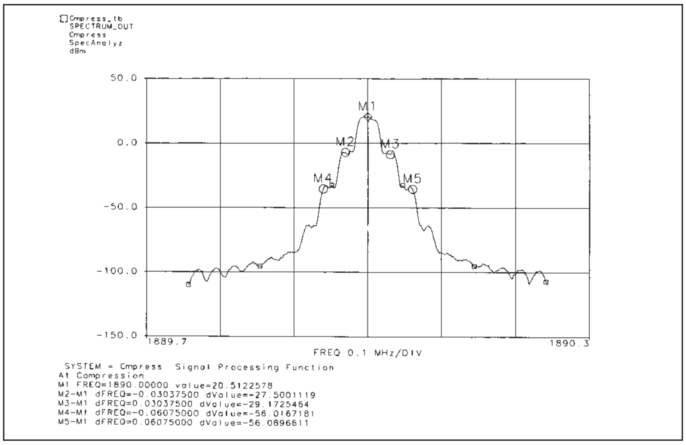
Figures 7 - 12 present the same type of a determination of ACP value as Figures 4 - 6, only at the other two



▲ **Figure 4. Power amplifier power output results.**



▲ **Figure 5. Spectrum of the input signal.**



▲ **Figure 6. Output signal spectrum.**

levels of output power. Let us briefly note, that from Figure 7, it follows that the gain at the power level exceeding 1 dB compression by 1 dB is only ~ 26 dB. At the same time the ACP value is still theoretically in spec (better than 26 dB, Figure 9). From Figure 10 it follows, that the gain at the power level below 1 dB compression by 3 dB is ~27.2 dB. At this level the ACP value is ~31.5 dB, shown in Figure 12.

Explanation of obtained results

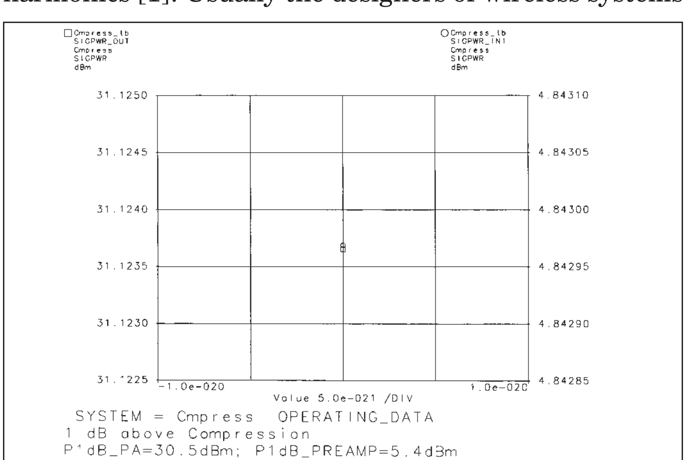
The measure of linearity for digitally modulated signals is Adjacent Channel Power (ACP). The measure of linearity for continuous wave (CW) signals is 1 dB compression. In the previous paragraph we saw that there is a correlation between those terms. Here we are going to find the reason for that correlation.

CW linearity terms

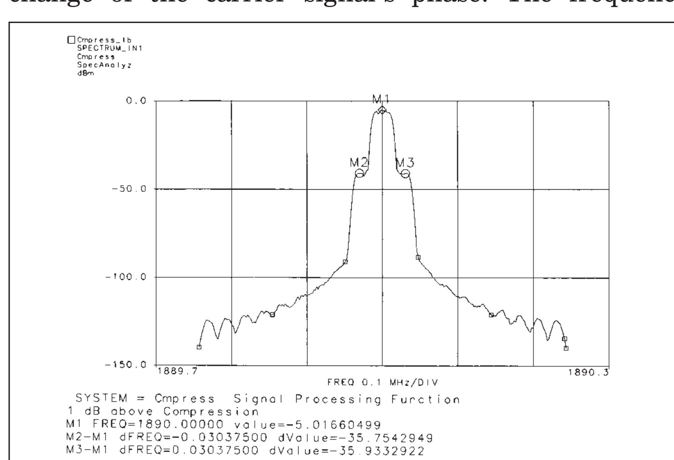
The problem with the system's nonlinearity is in its spreading of the input signal's spectrum. If we have a CW signal at the input of the nonlinear system, the spectrum spread is realized only in a creation of higher order harmonics [1]. Usually the designers of wireless systems are not excessively concerned of them though, since it is relatively easy to filter them out. The problem becomesmore serious when the signal at the input of a nonlinear system is an amplitude modulated. It is easy to show that an amplitude modulated signal is represented in the frequency domain by a combination of several CW harmonics. They are going to be of various frequencies and amplitudes. The nonlinearity of the system this signal is applied to creates additional harmonics. The degree of nonlinearity for each of these harmonics is determined by the CW linearity terms, specifically by the system's value of 1 dB compression. The output spectrum will include all harmonics of the input frequencies as well as their geometrical sums, or intermodulation products. When their order is 3 times higher than the order of input frequencies, they are called Third Order Intermodulation (IM) products. The higher the value of the input signal's power for the given value of 1 dB compression, the more pronounced third order products are. It is unrealistic to filter them out, since their frequencies are close to the frequencies of input carrier and modulation components. This type of spectrum spread results from a system's nonlinearity.

Linearity terms for digitally modulated signals

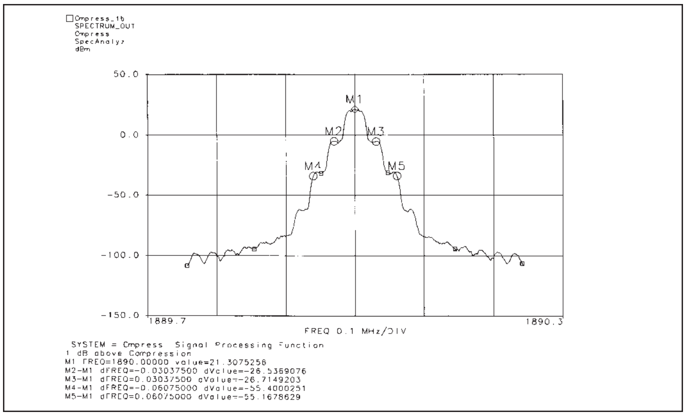
The signals we are examining are not CW ones. They are digitally modulated signals. According to the requirements of IS136, the system uses a phase modulation. Previously, we described in detail the generation of a TDMA signal. To repeat the basics here, the phase modulation is realized in the following way: The bit stream consisting of pulses with the same magnitude but various signs is generated according to the data requirements. The amplitude adjustments to the bit stream are done to create a required constellation diagram. Then the resulting bit stream is modulated by the sinusoidal signals, usually according to eq. (1). It creates a time domain presentation of the continuous bit stream. Each bit is distinguished from any other by the change of the carrier signal's phase. The frequency



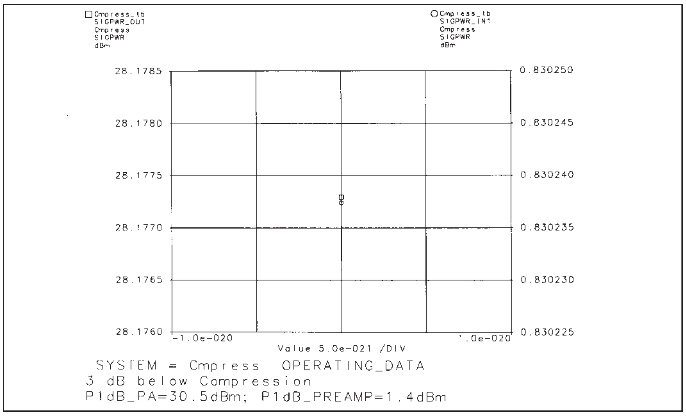
▲ **Figure 7. Power amplifier output, 1 dB above P_{1dB}.**



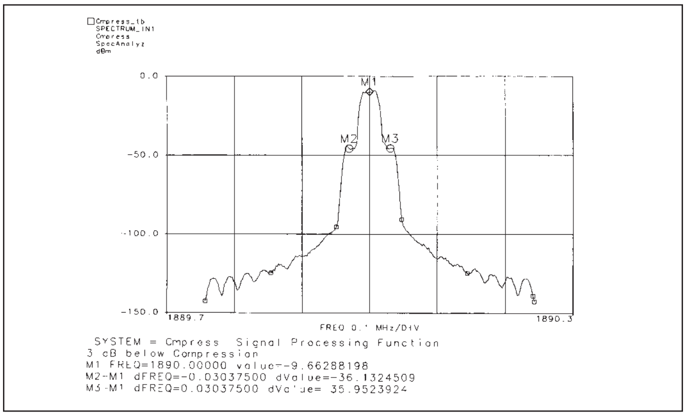
▲ **Figure 8. Input signal spectrum, 1 dB above P_{1dB}.**



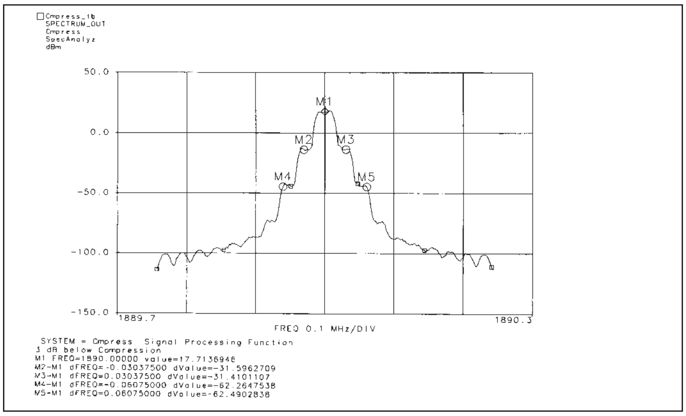
▲ **Figure 9. Output signal spectrum at 1 dB above P_{1dB}.**



▲ **Figure 10. Power amplifier output, 1 dB below P_{1dB}.**



▲ **Figure 11. Input signal spectrum, 1 dB below P_{1dB}.**



▲ **Figure 12. Output signal spectrum at 1 dB below P_{1dB}.**

domain presentation of that bit stream may spread the spectrum over the boundaries designated by the standard. The limit for the spectrum spread is set by the value of ACP.

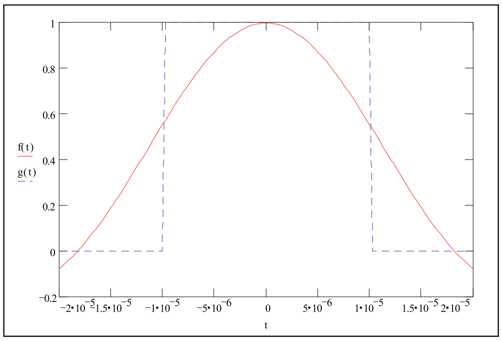
The phase modulated signals we are examining though, should behave as single frequency CW ones. The reason for that is in the bit length referenced to the carrier frequency. For the RF frequencies (~800 MHz) the duration of each bit (~20 msec) is long enough to ignore the discontinuities caused by the modulation. So, seemingly, no matter what a degree of system nonlinearity, the spectrum should not spread to any adjacent channels. The effect of the systems nonlinearity should be realized only in the creation of higher harmonics.

However this is not the case. It is a well known fact that the system's nonlinearity worsens the value of ACP, that is, it does spread the spectrum to the adjacent channels. This fact was confirmed by the simulation described earlier. The reason for the spectrum spreading to the adjacent channels is in the signal shaping.

Shaping

The shaping is done to reduce inter-symbol interference. It is implemented by the Gaussian-type Root Raised Cosine filters. The shaping is causing the phase-modulated signal to have properties of an amplitude modulated one [2].

The application of signal shaping to the input bit stream is illustrated on the graph below, taken from [2]. The dashed line represents a single unshaped bit. The solid one shows the same bit after a shaping application. Clearly after the shaping application, the input signal does not have a constant amplitude any longer. It becomes an amplitude-modulated signal. The appearance of the amplitude modulation explains the spectrum spread to the adjacent channels. To understand the degree of the spread we must look at the properties of Gaussian-type pulses.



One of the important features of the Gaussian-type pulses is that they have the same representation in both time and frequency domains. In the frequency domain this representation could be thought as a number of discrete harmonics infinitely close to each other. The harmonics when applied to the input of a nonlinear system are going to create intermodulation products. Some of the products appear at the frequencies of adjacent channels, creating an effect of spectrum spread into those channels. As a result, the measure of the spectrum spread, ACP, is worsened.

ACP is a linearity term for digitally modulated signals. Third order IM products is a linearity term for CW signals. By explaining the dependence of ACP on IM products we had established in principle the correlation between digital and CW linearity terms.

As an example, let's examine which of the input harmonics can create a spread of a spectrum into adjacent and alternative channels. According to the IS-137 requirements for ACP measurements, we are interested in the value of relative powers at f_0 ±30 kHz (for adjacent channels) and f_0 ±60 kHz (for alternate channels). The third order products are the ones appearing at frequencies of $\pm f_1 \pm 2f_2$ or $\pm f_2 \pm 2f_1$. So one of many combinations for creation of third order products could be as given in Table 1.

It confirms that the spread of a spectrum for Gaussian-type pulses is realized by the third order products created because of the pulse shaping. The result states that there is some correlation between digital linearity terms (spread of the spectrum to adjacent channels, described as ACP) and CW linearity terms (third order products). Now we can figure out the degree of the correlation.

Correlation between terms

We want to find a correlation between ACP and P_{1dB}. In the previous section we confirmed that in our case the spread of a spectrum is realized by the third order IM products. Now we have to find the degree of correlation. That is, we have to figure out the functional dependence (if any) between the terms.

We know that an ACP increase is caused by IM products. It would be natural then to determine the value of IM products as a function of a system's CW linearity measure. The most common method to calculate IM

f_1	f_2	$2f_1–f_2$	3rd order product
f_0+10 kHz	f_0–10 kHz	f_0+30 kHz	Adj. Channel I
f_0–10 kHz	f_0+10 kHz	f_0–30 kHz	Adj. Channel II
f_0+15 kHz	f_0–30 kHz	f_0+60 kHz	Alt. Channel I
f_0–15 kHz	f_0+30 kHz	f_0–60 kHz	Alt. Channel II

▲ **Table 1. IM products on adjacent and alternate channels.**

products is the so called 2-tone test. According to it, two signals with the same amplitude and different frequencies are applied to the input of a system. The system's nonlinearity creates harmonics and IM products. The level of those products can be used as a measure of a system's linearity (as a substitute for 1 dB compression).

Let's use 2 tones with the amplitude values causing the system's gain to be compressed by 1 dB. If we determine the resulting level of IM products created in that case, we establish the degree of the sought correlation.

Each nonlinear system can be described by:

$$e_{out} = k_1 e_{in} + k_2 e_{in}^2 + k_2 e_{in}^3 + \ldots \quad (2)$$

The input signal is a 2-tone one, described by the formula:

$$e_{in} = A[\cos(\alpha) + \cos(\beta)] \quad (3)$$

Using straightforward calculations, we obtain, that the amplitude of the output signal at each of the fundamental frequencies is [1]:

$$e_{fund} = k_1 A + 9/4\, k_3 A^3 \quad (4)$$

The amplitude of the output signal at each of the intermodulation frequencies is [1]:

$$e_{IM} = 3/4\, k_3 A^3 \quad (5)$$

Gain compression (g_c) is defined in [1] as the ratio of the output signal at each of the fundamental frequencies to the same signal for a linear system, that is for the system with $k_2 = k_3 = \ldots = 0$.

$$G_c = 20\log(g_c) = 20\log(e_{fund}/k_1 A) = 20\log(1 + 9/4\, k_3 A^2/k_1) \quad (6)$$

The value of intermodulation products can also be defined in a relative term, as a ratio. The value of a relative third order intermodulation product is defined in [1] as the ratio of an output signal at the intermodulation frequency to one of the input frequencies. In our case each of the two main frequencies is the same. It coincides with the value of the signal for a linear system we used in (6), that is it is $k_1 A$. The relative third order intermodulation product is found:

$$r_{2ab} = e_{IM}/\, k_1 A = 3/4\, k_3 A^2/\, k_1 \quad (7)$$

Substituting (7) into (6) we get the following correlation between the gain compression and the relative third order Intermodulation product:

$$G_c = 20\log(1 + 3r_{2ab}) \quad (8)$$

or, conversely,

$$R_{2ab} = 20\log(r_{2ab}) = 20\log((10G_c/20 - 1)/3) \quad (9)$$

Formulas (8) and (9) determine an interdependence between relative values of third order IM products and the system's gain compression. This is the correlation we want to establish. However we want to quantify the spectrum spread at the specific value of the gain compression. The gain has to be compressed by 1 dB. Substituting $G_c = 1$ into (9) we obtain the sought correlation:

$$R_{2ab} \approx 28 \text{ dB} \quad (10)$$

The result is a relative value of 2-tone third order IM distortion when two input tones of equal amplitude compress the system's gain by 1 dB. It is a fixed value, independent of system's parameters. The significance of it is that it confirms that both parameters (P_{1dB} and IM products) are just different forms of the description of the system's linearity.

The next step in the process of determining the correlation between ACP and P_{1dB} is to find a value of a correlation between a relative value of third order IM products and ACP. It happens that these two notions represent the same value. The difference between them is in the fact that the relative values of third order IM products represents a CW measure of linearity, while ACP is a measure of linearity for digitally modulated signals. The justification of this statement is in the ACP definition given in IS-137 and in the shape of a Gaussian-type pulse. If we prove that the ACP can be determined from a 2-tone model, we will obtain the desired correlation.

The IS-137 standard defines ACP as a degree of spectrum spreading. ACP is a ratio of the signal power at the frequency of the adjacent channel to the signal power at the fundamental frequency. We already had justified that the spread to the adjacent channel is realized by the third order IM products. We had determined that the cause of the appearance of these IM products is in the presence of amplitude modulated pulses. The reason that a 2-tone method can represent a Gaussian-type pulse is in the specifics of the pulse's shape.

As discussed earlier, the frequency domain presentation of the Gaussian-type pulse could be thought of as an infinite number of discrete harmonics. Consequently, there is an infinite number of discrete harmonics creating a specific IM product. The way to have a better vision of the nature of this process is to average the amplitudes of all discrete harmonics above and below the carrier frequency. Since the amplitude of the harmonics is changing gradually from zero to the maximum (at the fundamental frequency) and back to zero, we obtain two averaged values each with the amplitude of half of the peak value of the pulse. In other words, we are coming to the conditions of the 2-tone method used in the above discussion.

The conclusion is that ACP is determined from a 2-tone model and the resulting ratio coincides with the simulated result given earlier.

The concept of averaging harmonics' amplitude also explains another seemingly controversial subject — the influence of the increase of a peak-to-average power ratio on the value of ACP.

It is known that shaping increases peak-to-average power ratio by ~3dB [3]. The increase happens because the Gaussian-type pulses are no longer contained in the boundaries intended for square pulses. The portion of the pulse spread into adjacent areas causes the increase of the resulting combined instantaneous amplitude.

It would seem that the value of average modulated power should be reduced accordingly by 3 dB. It would seem that the reduction is necessary to stay within the conditions of the 2-tone method.

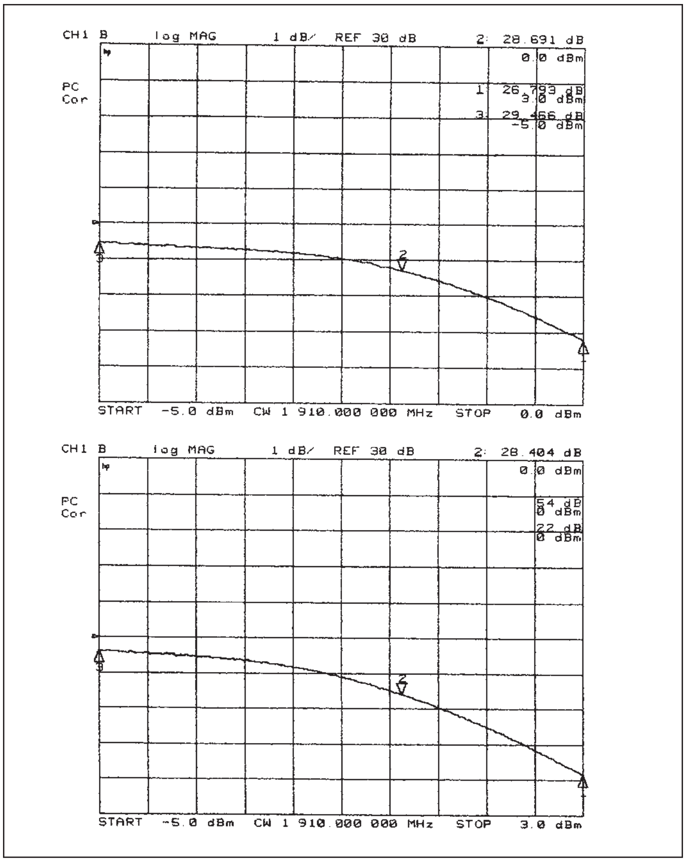
However the simulations show that we do not have to do any adjustments to the power levels for finding out ACP value for digitally modulated signals. The reason for it is again in the shape of a Gaussian-type pulse. As we discussed it earlier, the spectrum spread caused by IM products is described by a 2-tone method. All we need to know for application of that method is the equivalent value of each of two tones. Previously, to justify the application of the 2-tone method we used the concept of "harmonics' amplitude averaging." As it follows from [2] though, not all the harmonics of the Gaussian-type pulse are increasing evenly. Mainly, the amplitude increase is happening with the harmonics around the carrier frequency. The amplitudes of the majority of harmonics creating the IM products at the adjacent channel frequencies (30 kHz away from the carrier frequency) though, are small. At any rate they are small enough not to cause a compression in our nonlinear system. In order to justify the result in (10), all we need to have is the conditions for 1 dB compression. That is exactly the condition of simulations. In other words, the conditions of the 2-tone method are met.

Clearly, the increase of the peak-to-average power ratio would cause an overloading of our nonlinear system. However this overloading would mainly create an effect similar to a spectrum spreading by a single CW signal. That is, the spectrum spread realized by the increase of the peak-to-average power ratio would mainly create higher order harmonics of the carrier frequency.

We have now determined the correlation between ACP and P_{1dB}. It is a tool to predict a value of ACP as a function of a level of an output power.

Determination of ACP values

The IM products are causing the change in ACP. They are third order products. The order of products is determined by the order of the coefficients in the equation describing the system's linearity (2). Using this definition, the carrier frequency is the first order product. So



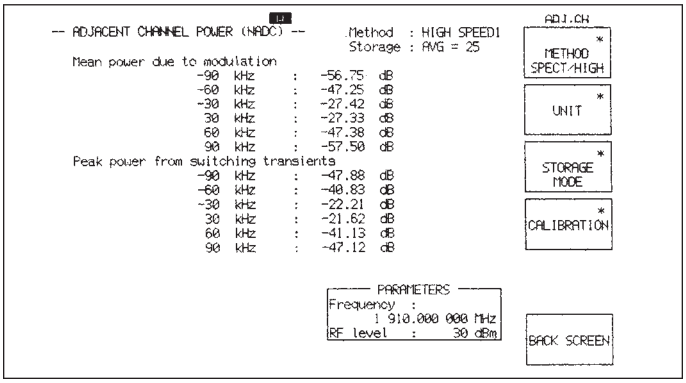
▲ **Figure 13. CW power measurements using the RF2513 power amplifier, to determine P_{1dB}.**

the value of IM products in dB varies three times faster than the corresponding value of a signal at the fundamental frequency. It sets up a simple 3:1 rule for determination of IM products and consequently ACP. That is an increase of the fundamental frequency signal's amplitude by 1 dB leads to the increase of the IM products' amplitude by 3 dB.

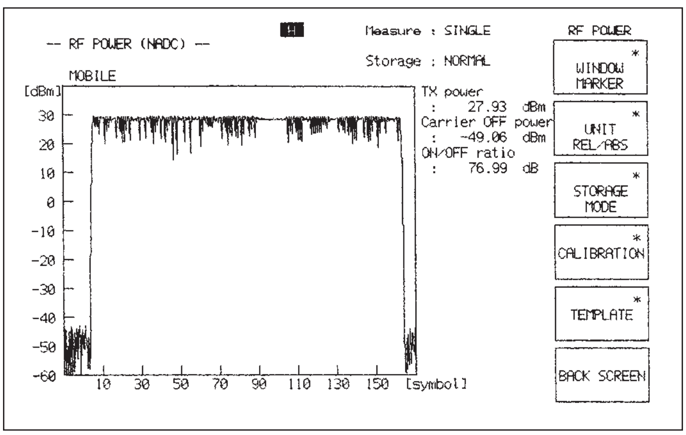
Let's apply this rule to the specific conditions at which we conducted the simulations.

From Figure 9, representing the condition when the input signal is increased by 1 dB above the value producing a 1 dB compression, it follows that the ACP is ~26 dB. From the 3:1 rule it follows that the IM products should increase by 3 dB. To come to their relative value, that is ACP, we have to subtract the value of the output signal increase, that is ~1 dB. So the value given by (10) should decrease by 2 dB to become 26 dB, which gives a close correlation with simulation results.

From Figure 12, representing the condition of the input signal value lower that the value producing a 1 dB compression by 3 dB, we get ACP value of ~31.5 dB. From the 3:1 rule it follows that the IM products should decrease by 9 dB. To come to their relative value, that is ACP, we have to subtract the value of the output signal decrease, that is ~3 dB. So the value given by (10)



▲ **Figure 14. ACP measurement results for the test amplifier.**



▲ **Figure 15. TDMA power measurement of the amplifier.**

should increase by 6 dB to become 34 dB. The reason of the discrepancy is in the method of ACP measurement required by IS-137. According to the requirements, the value of ACP is measured as a ratio compared, not to a maximum signal value, but to a signal value at the fundamental frequency. However, when the pulses combine, their peak can be shifted in frequency [2]. The actual ACP value could be reduced by as much as 2-3 dB. That explains the discrepancy and accounts for the difference.

It is worth noting that the initial value of ACP at the 1 dB compression (10) was obtained conservatively. That is the ACP of the signal modulated according to IS-137 requirements with an amplitude compressing an output by 1 dB is going to be better than 28 dB. Really, the result was obtained under the assumption that the combined value of equivalent (obtained by harmonics' amplitude averaging) 2-tones is compressing the output signal by 1 dB. We stated above that the actual value of any of the equivalent tones could be 2-3 dB higher. In order to obtain an actual value of ACP, the value of IM product should be referred to the value of an equivalent tone. It means that the when the value of the equivalent tone is increased, the resulting ACP value will improve.

This confirms that the nonlinear system compressed by 1 dB produces an ACP value (28 dB) acceptable for IS-137 with comfortable margin. At the same time any stronger compression of the system makes the ACP acceptance margin dangerously low.

Experimental confirmation

To confirm the validity of the obtained results we compare the simulation with the experimental data. Experiments were conducted on the 1 W power amplifier from RF Micro Devices, RF2513. It is an amplifier based on HBT technology. It requires two positive voltages to operate. We compared measurements of the CW and TDMA signals applied to the power amplifier biased with V_{cc} = 3.55 V and V_{mode} = 2.7 V.

The results of CW measurements are given in Figure 13. From this figure it follows that at the given level of DC supply the value of P_{1dB} is ~28.5 dBm.

The results of TDMA measurements are given in Figures 14 and 15. From these figures we conclude that at the output TDMA power of 28.2 dBm the value of ACP is ~27.5 dB, which is a reasonably good correlation with predictions (10).

Conclusion

In this paper we discussed the correlation between CW and TDMA linearity parameters of power amplifiers. We obtained the correlation value at the power amplifier 1 dB compression point. We determined that the ACP value at that point was 28 dB. This value was obtained from simulations and confirmed both by theoretical explanation and experimentally. It was justified that the nature of ACP is in IM products. The justification enables us to use a very simple 3:1 rule to predict ACP value at any given level of the output signal.

The conclusion of this result is that a power amplifier at 1 dB compression produces an ACP value (28 dB) acceptable for IS-137 with comfortable margin. At the same time, further compression of the power amplifier makes the ACP acceptance margin dangerously low. ■

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