

Adjacent Channel Power Ratio (ACPR)

Application Note



*ACPR Measurements Using the ME7840A
Power Amplifier Test System (PATS)*



Abstract

Adjacent channel power ratio (ACPR) is an increasingly critical measurement, particularly for power amplifier and amplifier subassembly manufacturers. This measurement is often time consuming, may require specialized equipment and has a significant potential for error. To have such a measurement incorporated into an integrated test system can radically reduce test time and expense. This note will explore such a system based on the Scorpion® family of instruments including the ACPR measurement options available, uncertainty issues, and some setup requirements.

Introduction

For many of the current and future transmission standards (IS-95 CDMA, WCDMA and variants, IS-54 NADC,...), ACPR (sometimes also termed adjacent channel leakage ratio-ACLR) is an important test parameter for characterizing the distortion of subsystems and the likelihood that a given system may cause interference with a neighboring radio. Since this distortion mechanism requires a non-linearity, the most important subassembly to check is one of the least linear: the power amplifier. As a result, many power amplifier test systems must incorporate provisions to measure this quantity.

ACPR and Intermodulation Distortion (IMD)

Even in early radio systems, the interfering effects of an active neighboring channel in mildly non-linear communications systems were well known. In these simpler modulation schemes, the use of two sinusoids to represent two active channels was considered adequate. The third-order product of these two tones (e.g., [2]) could land in a neighboring channel bandwidth thus causing interference. This was the beginning of two-tone intermodulation analysis. As the modulation becomes more complex, it becomes less obvious that the sinusoidal representation will adequately simulate the problem.

ACPR is the logical extension of the distortion measurement except that the two tones are replaced by a given modulated signal. Diagrams of these concepts are shown in Fig. 1. For obvious reasons, the interfering performance of the modulated signal is of critical interest to regulatory agencies and standards bodies [1].

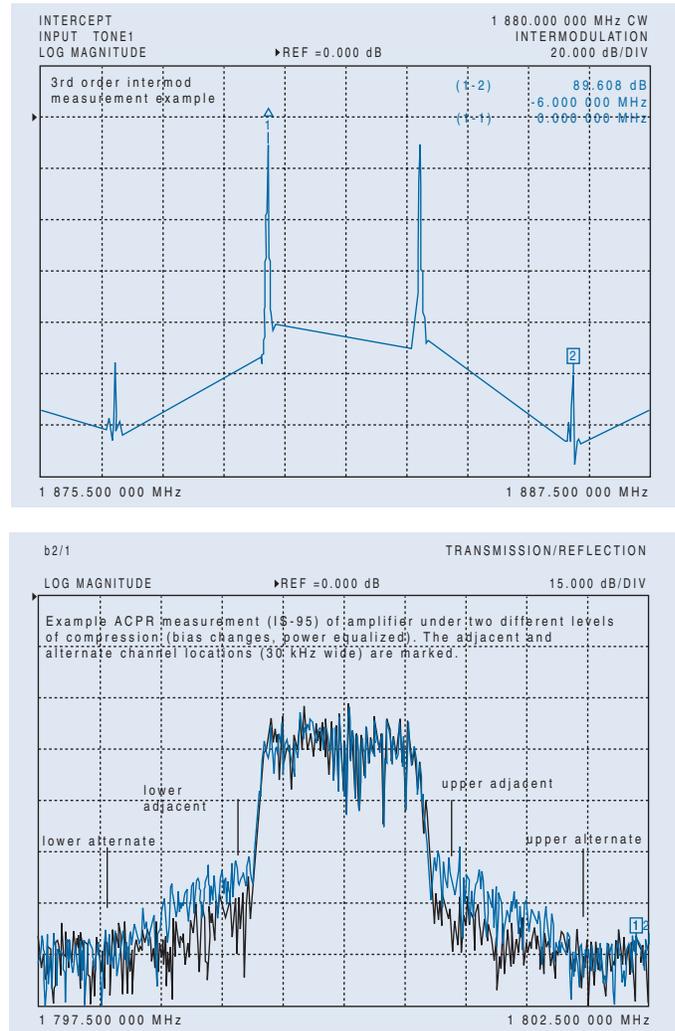


Figure 1. Example IMD and ACPR measurements are shown here. While the IMD measurement is simpler (requiring only 2 tones), it may do an inadequate job of predicting distortion performance under practical (i.e. modulated) conditions.

The 3rd order IMD product is usually defined as the ratio of the power in one of the third-order tones to that in one of the main tones. ACPR is defined as the ratio of power in a bandwidth away from the main signal (the distortion product) to the power in a bandwidth within the main signal. This statement is intentionally vague since the bandwidths and locations are functions of the standards being employed. Alternate channel power ratio is also sometimes defined and it refers to the ratio of power in a bandwidth two channels away from the main signal to the power in some bandwidth within the main signal. In terms of the IMD measurements, a 5th order product (or some combination of higher order products) may correspond to the alternate channel power ratio.

Because of the requirement for a modulated signal and the increased complexity in accurately measuring power over a precisely defined larger bandwidth, it has long been desired to avoid the direct measurement of ACPR and perhaps use IMD as a surrogate measurement. While in principle this is possible (perhaps using higher order IMD products) and is used in many cases, the correlation can be difficult since the relationship depends on the details of the amplifier topology as well as the modulated waveform being used (e.g., [3]-[6]). Thus in many cases, the true ACPR measurement must be performed.

Modulated Sources

A key component of this measurement is, of course, the signal generator. The channel bandwidths, the necessary measurement frequencies (relative to the carrier), the required filtering, and the receiver performance requirements are all a strong function of the type of signal provided. While many standards exist, two of the more common for ACPR measurements are of the spread spectrum CDMA variety: a narrowband and a wideband version. While the narrowband version has been standardized for sometime (IS-95, IS95A, IS-97...), the wideband standard is still in flux as of this writing but one fairly well-published configuration will be used here. Some current definitions of locations of measurement channels and their bandwidths are listed below for these signal types:

Type	NB CDMA IS-95 (rev link)	WB CDMA (one approach)
Main channel measurement BW	1.23 MHz or 30 kHz	3.84 MHz
Adj. channel location (from carrier)	± 885 kHz	± 5 MHz
Adj channel measurement BW	30 kHz	3.84 MHz
Alt channel location (from carrier)	± 1.98 MHz	± 10 MHz
Alt channel measurement BW	30 kHz	3.84 MHz

Aside from these characteristics, two other aspects of the modulated signal must be delineated:

- The total integrated output power of the DUT or total integrated power into the DUT is specified as part of the test. Much like IMD or any other distortion measurement, the level of distortion is a very strong function of source power level.
- ACPR varies strongly with the modulation format being employed, and within the spread spectrum classes, varies strongly with how the channel is loaded [7] (i.e., the detailed nature of the waveform must be provided for an apples-to-apples comparison). While it is beyond the scope of this note to explore the dependencies in any detail, it is critical for measurement comparisons that the channel configurations be the same. The dependence can largely be traced to the statistical distribution of power levels as a function of time. If the particular signal being used spends more time at higher power levels than a comparative signal, it is logical to expect a worse ACPR result with the first signal even if the RMS power levels are the same.

Modulation Measurements

Receiver Architectures

One decision that must be made is that of receiver type. Historically spectrum analyzers (or spectrum analyzer engines embedded in other instruments) have been used although vector network analyzer (VNA) engines can also be used. The latter choice has some advantages in integrating measurements.

In its most basic form, ACPR measurements are simply measurements of power ratios over some bandwidth. The first question then is how well suited are the various receiver architectures to making power measurements on quasi-stochastic signals.

Traditionally in spectrum analyzers, an envelope detector or similar circuit (final downconversion step) is used to extract a single amplitude value at each frequency. Scorpion, along with some other receivers, performs this final downconversion after the A/D process. An example VNA receiver, along with a typical spectrum analyzer receiver section, is shown in Fig. 2. It should be pointed out that many spectrum analyzer IF architectures exist and only one of the more complete examples is discussed here.

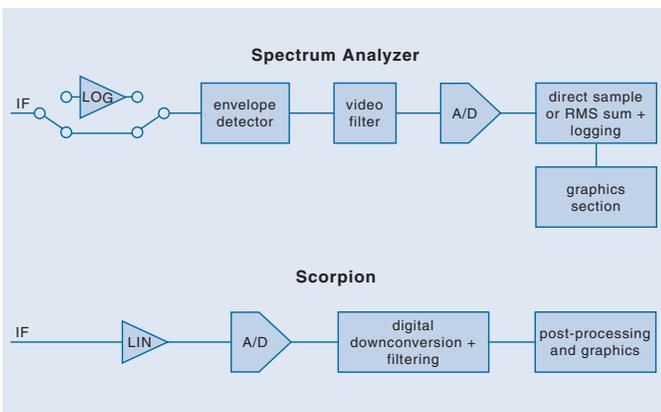


Figure 2. Example IMD and ACPR measurements are shown here. While the IMD measurement is simpler (requiring only 2 tones), it may do an inadequate job of predicting distortion performance under practical (i.e. modulated) conditions.

If the spectrum analyzer uses the log-amp path (only choice in older instruments) there are a number of errors introduced on modulated signals: (a) video averaging in the log domain is different from in the linear domain (equivalent for a CW tone) and (b) the noise power is quite different from the average noise level. Video bandwidth should be kept several times larger than the resolution or IF BW to avoid some of these problems. Sweep-to-sweep averaging may be used to reduce jitter in the data. This can also result in problems with noise-like signals in that the averaging may be erroneously performed on logged values. While modulation-specific corrections can be applied, this is a complicated process.

A better solution is to acquire multiple samples per frequency point (either at once or over several sweeps) and RMS average them in a linear sense. This avoids the distortions and corrections discussed earlier assuming enough statistically independent points are obtained. Some spectrum analyzers and the internal PATS/Scorpion receiver scheme implement this latter approach. In a true ACPR measurement, however, it is a ratio of two powers that is critical so that some of the disadvantages of the older technique described above do not strictly apply.

Special Considerations: Images and Spurs

Images and spurious receiver responses must also be considered. While these responses are not an issue in most spectrum analyzers, they must often be considered in VNA-based tools since these receivers are somewhat more general purpose, are optimized for speed, and are often double-sideband. Corrections for these are normally automatically provided either in instrument or test system software but one should be aware of them.

Since the Scorpion is a double sideband receiver, some care must be taken in handling the internal LO positioning and IF control. The adjustments are dependent on the channel bandwidth relative to the nominal system IF of 125 kHz and the frequency scale of variations. By making these adjustments, the main image effects can be removed. The first step is to always position the internal LO away from the main channel bandwidth when making adjacent or alternate channel measurements. When the channel width is comparable to or larger than the image spacing, then two passes of measurements are taken over the desired range (different LO spacings) so that the image contributions can be subtracted out. The resulting residual error, after the automatic corrections, is quite small (calculated to be normally much less than 0.1 dB).

Broadband or Narrowband Measurements

Both spectrum analyzers and Scorpion can easily lock onto a specific bandwidth over which to make the measurement; the question then is how is the power measurement performed within that bandwidth. If one has a very wide bandwidth receiver, one could sample the entire bandwidth at once for a very fast measurement. This is somewhat more difficult in the wider band systems (e.g., WB CDMA) although in some cases it is possible. Because of the use of a single, instantaneous power measurement, however, the accuracy is quite dependent on the shape of the spectrum and the details of the instrument's filter shape. While this can be corrected (and note that the correction will be dependent on the modulated signal waveform), it does increase uncertainty somewhat. This method also requires a resolution bandwidth that is very close to the desired channel bandwidth. While possible in principle with modern digital filtering, an exact match of bandwidths is sometimes not practical.

A more common technique is to use a smaller bandwidth on the receiver and take samples across the desired bandwidth. The selection of this bandwidth is important: too narrow and either the signal will be inadequately sampled or the measurement will take too long; too wide and there will be measurement error at the edges of the channel bandwidth.

A general rule of thumb is that the measurement bandwidth (either RBW in the case of spectrum analyzers or IFBW in the case of a VNA) should be between 1 and 3 times the step size and should be between 0.1 and 10% of the channel bandwidth. The latter ratio will slide depending on point density and any measurement bandwidth limitations. This level of coverage should avoid most power miscounts and lead to more reproducible results. A comparison of these techniques is shown in Fig. 3.

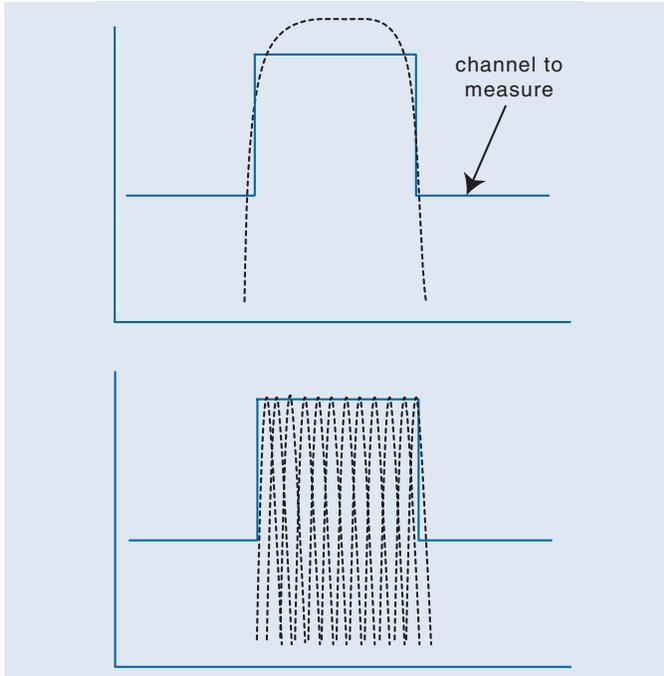


Figure 3. The difference between the single broadband measurement and multiple narrowband measurement approaches are schematically shown here. The wide measurement is faster but the effects of the measurement filter shape can be difficult to deconvolve. The measurement filter shape (shown as a dotted line) has less of an effect in the multiple measurement approach.

A summary of the characteristics of the two measurement approaches is shown in the table below. For many of the reasons shown and because of the flexibility of the receiver, this document will focus on the narrowband method. Although of less importance in the narrowband approach, the measurement filter shape must at least be considered. Most of the standard specifications dictate a given receiver filter shape (e.g., Gaussian, root raised cosine...) to properly emulate how the DUTs will actually be used. Most modern instruments have a provision for digitally setting the most common filter varieties although the impact on ACPR measurements is often small.

Approach	Advantages	Disadvantages
Narrowband	<ul style="list-style-type: none"> • Can quickly adapt to different signals • Rcvr filter shape less critical • Band edges easier to correct • Can trade speed for jitter 	<ul style="list-style-type: none"> • Usually slower
Broadband	<ul style="list-style-type: none"> • Fast 	<ul style="list-style-type: none"> • Must match rcvr BW to signal, may be difficult • Must correct for rcvr filter shape • Band edges harder to correct

High Level Test Set/Receiver Architecture and PATS

In order to improve test times, optimize designs, and improve large-signal performance, an integrated measurement system can help. The Power Amplifier Test System (PATS) was designed to enable many of the common PA tests with a single connection. A block diagram is shown in Fig. 4 that illustrates the high level structure of switching and high power couplers feeding a more general receiver. In the standard configuration, measurements such as S-parameters, compression, IMD, and some hot S-parameters can be performed. The switching and connections are already in place to allow the input of a modulated source (not integral to the Scorpion frame) required for an ACPR measurement.

A standard PATS block diagram is shown here. An external modulated synthesizer is required for the ACPR measurement and models from several different manufacturers can be controlled by PATS software. An external spectrum analyzer and/or the Scorpion receiver can be used for making the ACPR measurements (both can be used for comparative measurements).

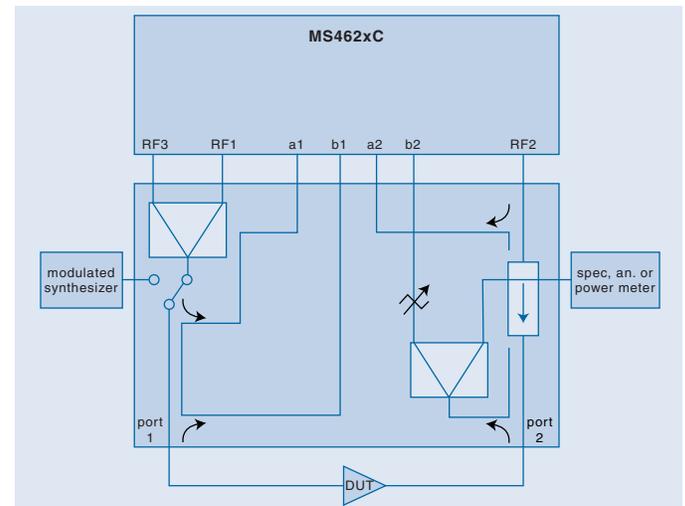


Figure 4. A standard PATS block diagram is shown here. An external modulated synthesizer is required for the ACPR measurement and models from several different manufacturers can be controlled by PATS software. An external spectrum analyzer and/or the Scorpion receiver can be used for making the ACPR measurements (both can be used for comparative measurements).

Switching is also available for an external receiver although the Scorpion itself can also be used for this purpose (thus reducing capital cost and space requirements). It is important to understand the similarities and differences in using Scorpion as the ACPR receiver compared to using an external spectrum analyzer. This will allow the user to determine equivalent setups and perform comparative analysis.

Dynamic Range Limits

Particularly in wideband CDMA and other broadband formats, dynamic range is at a premium and the limits must be understood. The primary constraints are receiver non-linearities at the high power end and receiver noise floor at the low power end. In some cases, internal LO phase noise provides a lower bound but in many current receivers, the noise floor itself is usually the lower limit. The calculations to follow will assume that Scorpion is being used as the receiver although a similar analysis can be done for any receiver.

The dynamic range limit can be found by computing the port-referred receiver noise floor, phase noise contribution and receiver-non-linearity contribution. This calculation will depend on the channel bandwidth (since this directly affects the noise contributions) as well as the statistical nature of the modulated waveform (since this affects the receiver non-linearities). In some cases, the receiver noise floor contribution can be reduced by carefully subtracting out its contribution to the measured result. Since the most challenging measurements to date are wideband CDMA with its large channel bandwidth, this calculation will be presented first.

It is assumed that the standard PATS test set is employed. If a different test set is used, the input power axis is scaled by the difference in test set loss from the port 2 connector to the b2 input port on the Scorpion. One wideband CDMA configuration (channel bandwidth of 3.84 MHz) was used in the calculation along with typical PATS/Scorpion parameters. It is also assumed that the 30 kHz IFBW setting is NOT used so that gain ranging will be enabled (this increases the dynamic range of the receiver).

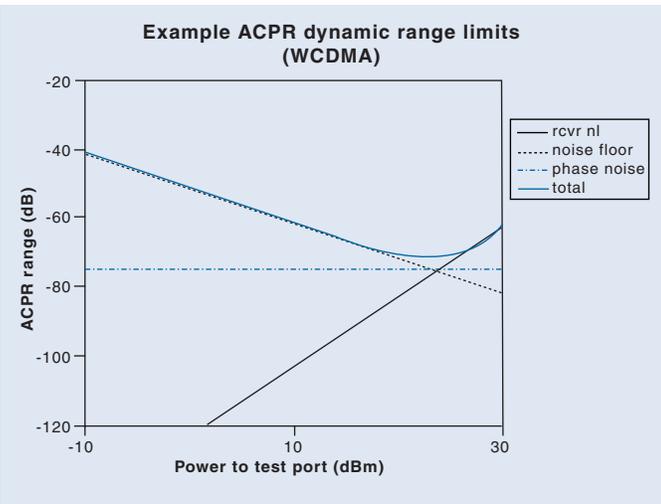


Figure 5. An example ACPR DR calculation for one type of wideband CDMA signal with the PATS/Scorpion configuration (0-dB receiver-side step attenuator setting) is shown here. Several assumptions go into this calculation but the optimal power range is between 0.1 and 1W for this setup. 'Power to test port' refers to power delivered into port 2 of the test set.

The three different components are summed on a linear power basis to create the 'total' curve in Fig. 5. As would be expected, the thermal noise floor dominates at lower input signal levels while receiver non-linearities dominate at higher levels. For this particular setup, a dynamic range of 63 dB can be obtained over an input power range of about 12-30 dBm and about 70 dB of dynamic range can be obtained for input powers of 19-26 dBm. The test set attenuator can also be used to shift this optimal range to higher power levels (subject to the power handling ratings of the test set).

A similar calculation for narrowband CDMA is shown in Fig. 6. The only difference here is the integration bandwidth and the effect of receiver non-linearities (since the peak to average ratio is different). Because the channel bandwidth is narrower, the noise floor contributions reduce and receiver non-linearities are a more significant issue. As a result, the optimal range drops in power (to slightly below 20 dBm into the test set with this attenuator setting) but the best dynamic range improves considerably. The ACPR definition using a 30 kHz sample in the middle of the main channel was defined for this calculation.

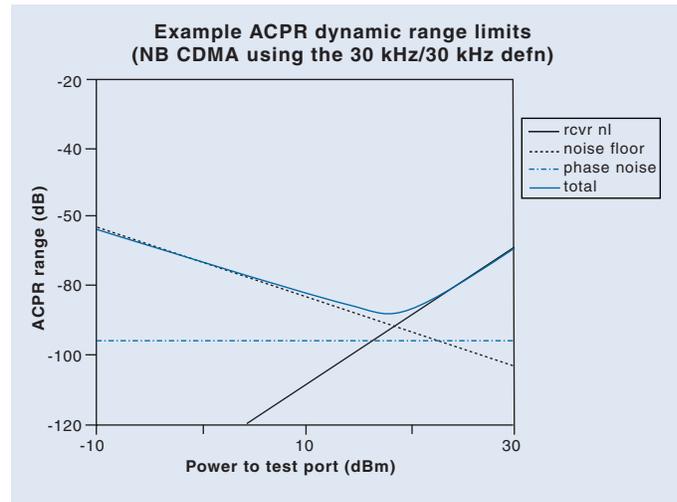


Figure 6. Another example dynamic range calculation with Scorpion/PATS and 0 dB attenuation is shown here, this time for a narrowband (IS-95) CDMA signal.

The optimal locations and available dynamic ranges are summarized in the following table. Note that subtracting the system noise floor from the data prior to the ratio being taken can extend the dynamic range. If done with an appropriate RMS averaging, the noise floor contribution can be reduced substantially.

Type	NB CDMA IS-95	WB CDMA
Optimum test set power w/ 0 step attenuation	14-20 dBm (25-100 mW)	19-26 dBm (80-400 mW)
Typical optimal ACPR dynamic range	85 dB (w/o noise subtraction) using the 30 kHz/30 kHz definition	70 dB (w/o noise subtraction)

To summarize the behaviors of different receiver types, the table below was constructed. As stated before, the comments are specific to the architectures pictured in Fig. 2 and may not be global. Resolution bandwidth (RBW) is a spectrum analyzer term that may be considered equivalent to IFBW (IF bandwidth), a VNA term.

Issue	Spectrum Analyzer	Vector Network Analyzer
Log amps in IF	<ul style="list-style-type: none"> Often present, causes errors with most digitally modulated signals Can be disabled in some instruments 	<ul style="list-style-type: none"> Not used
Averaging, sampling	<ul style="list-style-type: none"> Point-by-point averaging does not help jitter If done after logging, introduces errors Sweep-to-sweep can reduce jitter Instantaneous sampling has high jitter, RMS sampling can help 	<ul style="list-style-type: none"> Point-by-point averaging does not help, sweep-by-sweep averaging can help reduce jitter (done in RMS sense) Final downconversion often done digitally so RMS sampling can be done
Images & Spurious	<ul style="list-style-type: none"> Usually not an issue 	<ul style="list-style-type: none"> Must be corrected
Dynamic range	<ul style="list-style-type: none"> Dependent on rcvr noise floor, non-linearities and internal phase noise. Non-linearities often critical 	<ul style="list-style-type: none"> Dependent on rcvr noise floor, non-linearities and internal phase noise. Noise floor usually critical
VBW and Smoothing	<ul style="list-style-type: none"> VBW must be large relative to RBW. Particularly a problem if after logging 	<ul style="list-style-type: none"> Effective smoothing BW must be large relative to IFBW

ACPR Measurement Considerations

A number of the critical measurement issues have already been considered. In this section, an example measurement will be presented along with some of the decisions necessary to make the measurement itself and to compare to results measured previously.

Some of the details:

- DUT is an amplifier with a nominal operating output power of +26 dBm (about 25-30 dB gain)
- IS-95 test (offsets of 885 and 1980 kHz, adjacent and alternate channel bandwidths of 30 kHz, main channel bandwidth of 1.23 MHz)

Input signal with Pilot tone (Walsh code 0), Paging (Walsh 1), Synch (Walsh 32) and 6 traffic channels (Walsh 8-13). The reader can refer to some of the references, particularly [8], for the meaning of the Walsh codes. The important point is that the codes present in a given signal (and their associated powers) will affect the power statistics presented to the DUT and hence will affect the non-linearities and distortion produced.

Measurements to be performed at a variety of input power levels from -15 to 0 dBm. Expected ACPR levels in the -40 to -50 dBc range (using the 1.23 MHz main definition, -25 to -35 dBc using the 30 kHz main definition). For the alternate channel, the levels will be in the -60 to -70 dBc range (-45 to -55 dBc using the 30 kHz main definition).

Setup Using Dynamic Range Curves

Since this is an IS-95 measurement, one can refer to Figure 6. Based on the expected measured values, this measurement will not stress the dynamic range of the Scorpion/PATS system (probably over 45 dB of headroom in the optimal power ranges for adjacent channel, over 25 dB for the alternate channel). The optimal power range for this test system, from Fig. 6, would be a port power of 15-20 dBm. Thus at the higher power input ranges (greater than ~ -7 dBm), a step attenuator setting of 10 dB would be optimal. At lower drive levels, a setting of 0 dB will be optimal. An example measurement is shown in Figs. 7 (single power) and 8 (swept power).

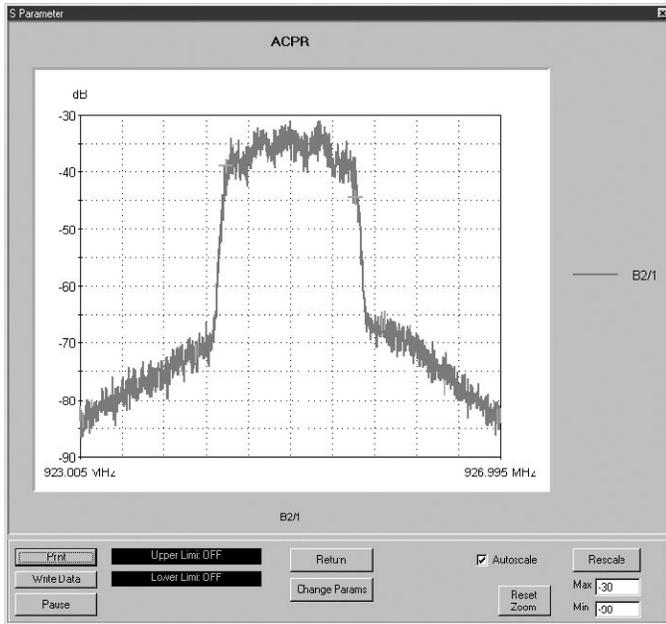


Figure 7. An example ACPR measurement of an amplifier at a single power is shown here using a narrowband CDMA (IS-95) input. The markers are positioned for channel measurements.

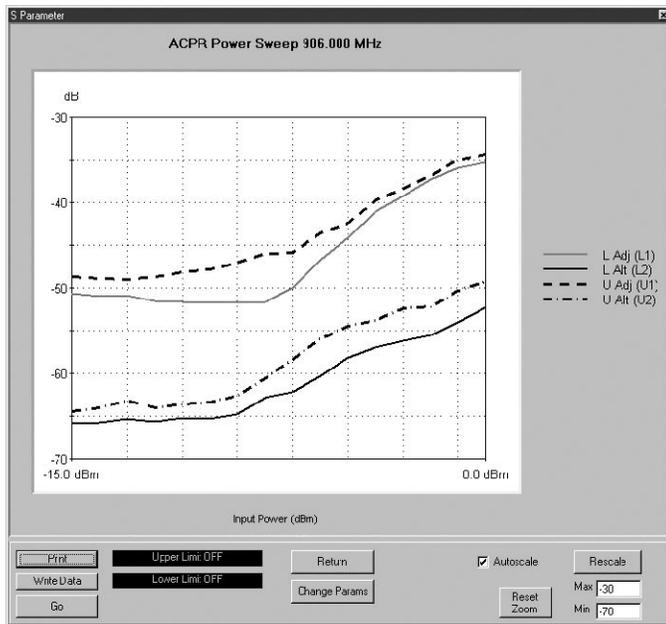


Figure 8. An example swept-power ACPR measurement is shown here for a narrowband CDMA (IS-95) input signal. Both upper and lower, adjacent and alternate channel measurements are shown.

Correlation Example

It is of interest to compare the measurement results using the Scorpion/PATS system to using a spectrum analyzer (also using the PATS test set). As shown in Fig. 4 and Fig. 9, the spectrum analyzer can be connected simultaneously to the test set to allow for easier comparison measurements. This helps remove the first two sources of potential disagreement shown below.

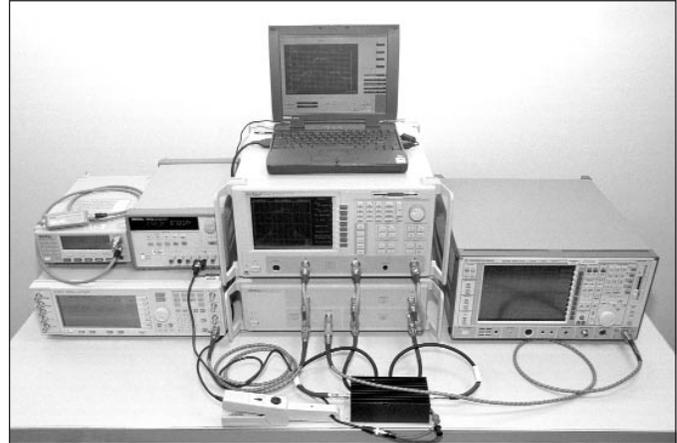


Figure 9. A typical correlation setup is shown here. An external modulated synthesizer and spectrum analyzer are simultaneously connected to facilitate correlation measurements.

Tips for correlation studies

- Make sure the source is setup exactly the same way (same total power, same channel allocations...i.e., the same waveform)
- Ensure that the match the DUT sees is comparable
- Ensure that both receivers are set for the appropriate place in their dynamic ranges
- Ensure that appropriate measurement bandwidths (both channel bandwidths and resolution/IF bandwidths) have been selected and that jitter levels are sufficiently low

In this particular case the match will be the same for the two measurements since the DUT sees the same coupler/splitter assembly all the time. The spectrum analyzer was set-up with (via its default settings for IS-95) a RBW of 30 kHz, a VBW of 300 kHz, no log-amp, and a reference level setting of -10 or -20 dBm (for high and low input powers respectively). The Scorpion was setup with an IFBW of 1 kHz, no trace smoothing (but with trace-to-trace RMS averaging) and the PATS attenuator settings listed above. Little difference was observed using an IFBW of 3 kHz in this particular case.

The comparison is shown in Fig. 10 for the higher level adjacent and alternate channels with a carrier frequency of 925 MHz. The comparison at two other carrier frequencies is shown in tabular form. The maximum difference was about 0.5 dB and since each instrument was showing jitter of about +/- 0.6 dB, the agreement seems reasonable. The maximum differences on the other adjacent and alternate channels were about the same. It can be expected that there will be larger differences as one starts to stress the dynamic range of one or both instruments.

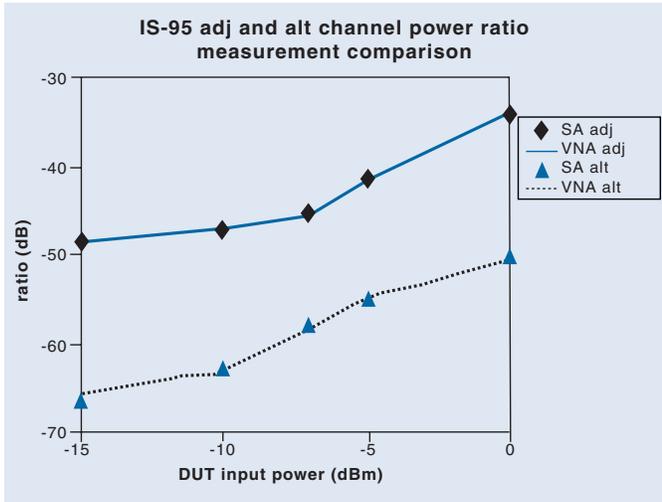


Figure 10. A comparison between measurements using a spectrum analyzer (SA) and using a Scorpion VNA (both using a PATS test set) is shown in this graph. The configurations were carefully setup to be comparable. The carrier frequency was 925 MHz.

Carrier frequency	Channel/inst	887 MHz	905 MHz
Pin= -10 dBm/ Pout= 18 dBm	Adj SA	-50.5	-47.9
	Adj VNA	-50.4	-47.9
	Alt SA	-64.9	-63.7
	Alt VNA	-64.6	-63.8
Pin= -5 dBm/ Pout= 23 dBm	Adj SA	-43.8	-42.7
	Adj VNA	-44	-42.5
	Alt SA	-56	-54.9
	Alt VNA	55.9	-55.1
Pin= 0 dBm/ Pout= 28 dBm	Adj SA	-35	-34.9
	Adj VNA	-35.2	-35.2
	Alt SA	-50.6	-49.8
	Alt VNA	-51	-49.6

A second correlation example was constructed for wideband CDMA and a different test DUT. As in the previous example, the spectrum analyzer will be connected to the test set access port so that the DUT sees a consistent match. As discussed earlier, this measurement is more likely to stress the dynamic ranges of the receivers. The spectrum analyzer was setup (via default settings for this standard) with a RBW=30 kHz, no log amp and a reference level setting of -20 or -30 dBm (for high and low input powers respectively). The Scorpion was setup with an IFBW of 10 kHz (to keep gain ranging), no trace smoothing (but with trace-to-trace RMS averaging) and PATS attenuator settings of 0 or 10 dB (for DUT output powers above 26 dBm, 10 dB was used) based on the dynamic range curves shown previously.

The wideband CDMA (measurement bandwidth of 3.84 MHz at offsets of 5 and 10 MHz) comparison is shown in Fig. 11 for the higher level adjacent and alternate channels. The carrier frequency for this plot was 1850 MHz. The maximum difference in this case was about 1 dB and occurred at the lowest power levels. The jitter levels were higher in this measurement since the signals being measured were closer to the receiver noise floors. This tends to explain the slightly larger separations. The alternate channel data are not plotted for lower drive levels since these measurements were basically at the dynamic range limits of both receivers for this setup.

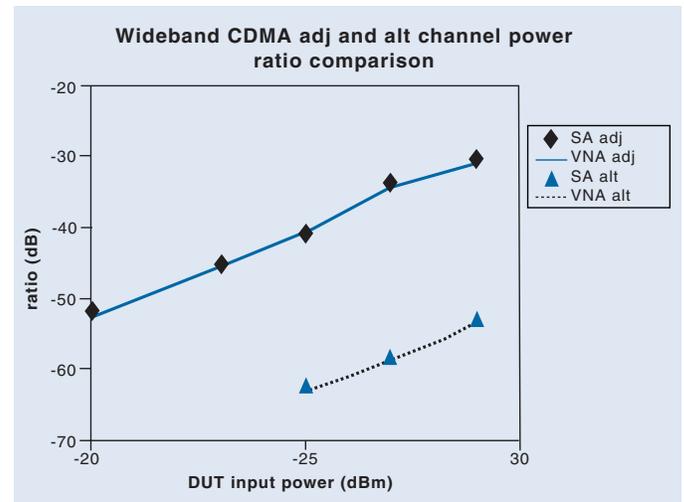


Figure 11. A comparison between measurements using a spectrum analyzer (SA) and using a Scorpion VNA (both using a PATS test set) is shown in this graph for a wideband CDMA configuration.

Comparison With IMD Example

Because of the complexity of the ACPR measurement, a common request is to compare against a two-tone IMD measurement to see if the latter can be used as a proxy. To continue with the previous IS-95 example, an ACPR power sweep will be plotted against an IMD power sweep (3rd, 5th, and 7th order). The same test set was used (note from Fig. 4 that the combiner required for IMD is already present). The IMD tone separation was set at 600 kHz to roughly mimic the bandwidth used by the modulating signal. The input power axis for the IMD measurement refers to the tone 1 power while it refers to the total input power for the modulating signal (thus some care is required in interpreting power levels). The purpose of this comparison is to look at the curve shape more than the absolute values involved since some lookup table could be constructed for the latter if the behaviors are similar. These curves are shown in Figs. 12 and 13 for the upper and lower products respectively (only adjacent channels are shown here for clarity).

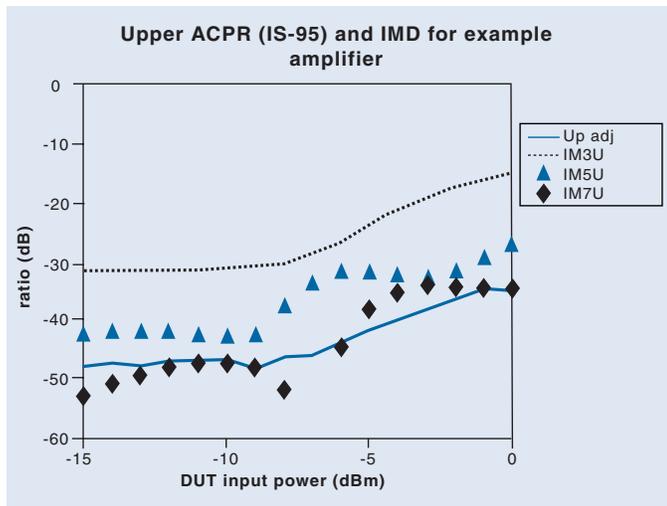


Figure 12. ACPR and IMD swept power measurements are shown here for an example amplifier. The products higher in frequency than the carrier are shown in this plot.

There has been much analysis and discussion in the literature as to how this data should be analyzed and what other measurements are required. Such discourse is beyond the scope of this note, the main point is that such measurements can be made under roughly equivalent conditions to ease such analysis. One interesting note is the dip in IM3L (lower 3rd order IMD product) corresponds to a slight dip in ACP lower. When the IM3 dip is smaller on the upper sideband (IM3U), the upper ACP dip also shrinks. Such analysis could be carried out over different frequencies and over different power ranges as well in order to establish a more complete picture.

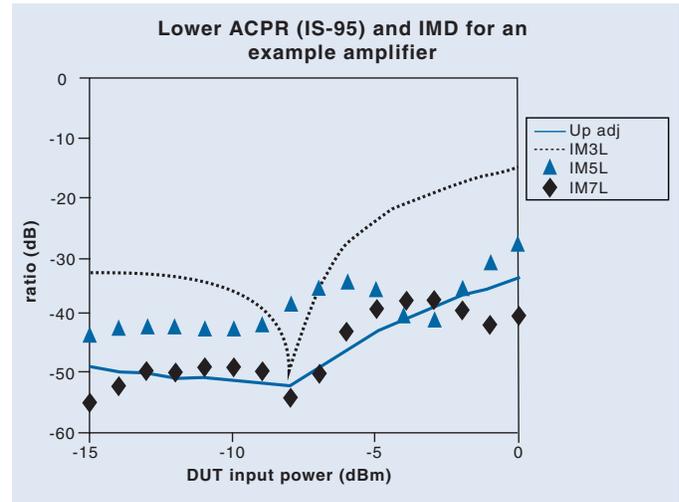


Figure 13. ACPR and IMD swept power measurements are shown here for an example amplifier. The products lower in frequency than the carrier are shown in this plot.

Uncertainty Analysis

The uncertainty in this measurement is almost exclusively due to the raw power measurement and is composed of several factors:

More significant

- Dynamic range-related errors
- Jitter

Less significant

- Spurious response errors
- sampling rate and/or filter shape induced uncertainty
- raw A/D linearity errors
- match-induced errors
- Other absolute power measurement uncertainties (proportional)

It is assumed that only the power ratio is of interest so proportional power uncertainties can be ignored. In this model, the filter shape and sampling rate-induced uncertainties tend to cancel out except perhaps errors incurred at the edges of the main signal. It is assumed that this region is handled properly. Uncertainty due to jitter is also removed from this model; it is assumed that a large enough number of samples are employed. This is usually a trade-off against measurement time and is an important consideration. It is also assumed that the source has sufficiently low residual ACPR (generally assumed at least 10 dB below that of the DUT) so that it does not contaminate the measurement. These comments are valid no matter what receiver is being used.

Generally the A/D linearity errors are so small that they can be ignored. An exception to this may occur with unusual waveforms in that clipping can occur with high peak powers. The clipping level will occur in the vicinity of +40 dBm with the standard Scorpion/PATS test set and 0-dB attenuation.

Match-induced errors are rarely a problem since the frequency spans are relatively small (for the RF communications standards discussed). There may be pathological cases involving strong resonances but those are not considered here.

With these assumptions and using Scorpion as the receiver, the dominant source of uncertainty will likely be the proximity to the dynamic range limits along with some residual, uncorrected spurious contamination. An estimate of an uncertainty floor (far from the limits) is about 0.25 dB plus jitter for WCDMA (a bit less for narrowband CDMA since the image uncertainty is less of an issue). If a different receiver is being used, the floor uncertainty may be higher or lower depending on architecture. At the dynamic range limit, there will be an additional uncertainty of 3 dB. At 10 dB away from the limit, this added uncertainty will drop to below 0.5 dB. At 15 dB away, the added uncertainty is only about 0.1 dB. These added uncertainties are independent of receiver type although the location of the dynamic range limit is a strong function of the receiver design.

Summary

Some of the details of the ACPR measurement on a Scorpion/PATS-based measurement system have been discussed. The test set is configured to allow the connection of a modulated signal source and the use of either Scorpion as the receiver or an external spectrum analyzer. When using both receiver types, some comparative measurements can be performed and agreement within jitter and uncertainty expectations can be obtained. Some measurement pitfalls and issues were discussed along with expected dynamic range and uncertainty limits when using Scorpion as the receiver.

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