Application Note

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Accurate power measurements using spectrum analyzers

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The IFR 239X series spectrum analyzers from Aeroflex run automatic power measurement functions dedicated to modern digital radio systems testing.

These systems use modulation techniques that make generated signals difficult to measure using standard methods, and quite impossible with RF power meters when interferers or other channels are present together with the signal. In this case, a spectrum analyzer is the best tool to use if fitted with dedicated power measurement functions.

To cover these requirements, Aeroflex has developed a comprehensive range of spectrum analyzers, the 239X series, with models from 9 kHz to 3, 13 and 26.5 GHz.

All the instruments of this family have a set of semi-automatic measurement functions that include the following:

- X dB Down, measuring the X dB bandwidth of a system
- Adjacent Channel Power, measuring the channel power and the difference between channel power and adjacent channels power
- Channel Power
- Occupied Bandwidth; measuring the system bandwidth containing X% of the channel power
- Harmonic Distortion ; measuring up to 5 harmonic frequencies within the signal, and calculating the THD of the signal

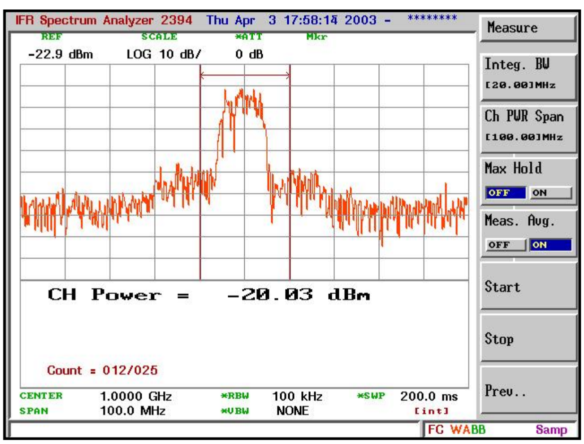
The aim of this application note is to provide information allowing for better use of the power measurement functions, to explain the measurement method employed and to highlight the causes for inaccuracy.

Measurement principle

Power measurement is performed in a spectrum analyzer by integrating several elementary power samples taken at different frequencies over the resolution bandwidth of the analysis filter (RBW). Theoretically, it is necessary to know precisely the equivalent noise bandwidth (ENB) of each analyzer's filter. In the real world, this bandwidth is very close to the analysis filter's bandwidth (RBW) but it can vary according to the shape of the filter.

Then it is necessary to take the samples at frequency intervals equal to the equivalent noise bandwidth of the filter in use. In the real world, the integration bandwidth does not exactly match an entire number of ENB's and therefore, must be much higher than ENB in order to limit uncertainty to ± ENB.

The following example shows the RBW filter set at 100 kHz while the integration bandwidth is set at 20 MHz. The span has been adjusted around 4/5 times higher than the signal bandwidth.



On top of that, each sample must represent a real sample: when entering this measurement mode, the spectrum analyzer automatically switches to the "Sample" detection mode. The power measurement is processed using real samples taken at the display points (different from the normal spectrum analyzer mode where "Peak Pos" is normally used).

Every sample must be statistically independent therefore the video filter must be switched off (or set at the maximum value) and trace averaging not used.

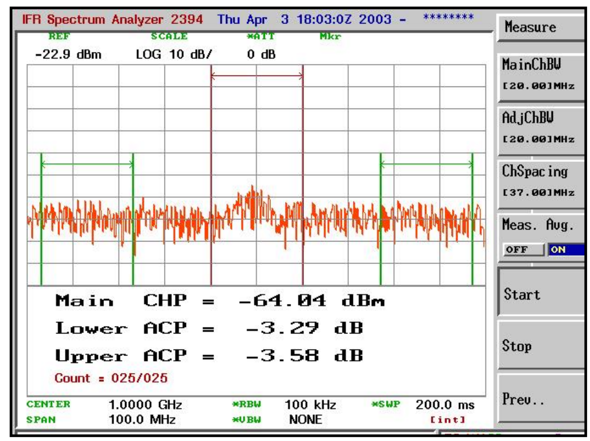
The soft keys of the IFR 239X series spectrum analyzers allow the operator to set up integration bandwidth (Integ.BW) and channel span (Ch.PW Span) parameters using the keyboard or scroll knob. The integration bandwidth is shown on the screen using two red vertical lines.

The lower part of the screen is dedicated to the digital display of the measurement results. A more stable display is obtained using measurement averaging, without any negative effect on accuracy. Display rate can be reduced by lowering the sweep speed.

Special case - Low signal measurement

When the signal level is not far from the noise floor, accurate measurement is possible if the noise power is taken into account and the measurement result corrected. In this case, the "Adjacent Channel Power" measurement will be used as it will allow for measuring the noise power in the same bandwidth. The operating mode is identical and the same precautions as for "Channel Power" are taken.

The soft keys of the IFR 239X series spectrum analyzers allow the operator to set up the main channel bandwidth (MainChBW), the adjacent channel bandwidth (AdjChBW) and the channel spacing (ChSpacing). The first two parameters must be set up at the same value and spacing must allow for the display of adjacent channels on the screen.



The measurement results are displayed on the lower part of the screen. Correcting the measurement will start with calculating the average value of adjacent channel power differences.

$\Delta = 0.5 \times [(-3.29) + (-3.58)] = -3.43$ dB

The correction factor C is computed using the formula:

$C = 10x\log(1-10^{\Delta/10})$

The following table gives some of the most useful values:

Power difference	Correction factor
-3.0	-3.02
-3.5	-2.57
-4.0	-2.2
-4.5	-1.9
-5.0	-1.65
-6.0	-1.26
-7.0	-0.97
-8.0	-0.75
-10.0	-0.46
-15.0	-0.14

According to this table, it is not necessary to use any correction factor when the power difference is higher than 15 dB. For low differences, correcting the result becomes mandatory.

In our example, the corrected value of the channel power is :

ChP = -64.04 -2.57 = -66.63 dBm

Comparing with an RF power meter

Advantages of using the IFR 239X series:

- Selective measurement : it is possible to measure one particular channel among others (satellite reception) or when interferers are present
- High dynamic range (typically +30 dBm to -80 dBm), no sensor to change
- Better accuracy at low levels, due to correction capability

Drawbacks:

- Slightly less accurate for middle or high levels
- Measurement time slower
- Not usable on pulsed signals

IFR 239X series Spectrum Analyzers

The family includes 4 units in the same mechanical design:

2397 - 9 kHz to 3 GHz, monochrome display with optional DC power supply and battery

2399A - 9 kHz to 3GHz, color display, switchable low noise preamplifier

These two units may be fitted with an optional 100 kHz to 3 GHz tracking generator to allow VSWR and Cable Fault measurement functions to be performed with the spectrum analyzer.

2394 - 9 kHz to 13.2 GHz, color display , designed for spurious signal identification on digital radios

2395 - 9 kHz to 26.5 GHz, color screen fitted with Planar Crown type N or APC7 compatible SMA input connector

All these units can be delivered with the High Stability Time Base option, EMC filters and quasi-peak detectors option and EMC software facilities. A digital filter option, reducing the analysis bandwidth to 10 Hz is available for all models except the 2397. They all have a 3 1/4" floppy disk drive as standard, RS232, IEEE488, parallel and VGA interfaces, and are delivered in a soft transport case.

Screen dumps can be produced either on a suitable printer or floppy disk using Bitmap or JPEG formats.

The EasySpan application software from Aeroflex allows for file transfer to PC and export of data in many formats.

More information on Aeroflex products can be obtained from your local Aeroflex rep or on the Aeroflex web site at www.aeroflex.com.

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