

# Measuring ACLR/CACLR for Non-contiguous Carrier Aggregation

3GPP TS34.141 Release 12 Base Station  
Adjacent Channel Leakage Power Measurement

**MS2690A/MS2691A/MS2692A/MS2830A**  
Signal Analyzer

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## Introduction

This application note explains how to measure Adjacent Channel Leakage Power Ratio (ACLR) with reference to 3GPP TS36.141 V12.2.0 (2013 to 2012). This application note also gives examples of how to measure the ACLR and CACLR for non-contiguous carrier aggregations using the Anritsu MS269xA series of spectrum analyzers.

ACLR is the ratio of the filtered mean power centered on the assigned channel frequency to the filtered mean power centered on an adjacent channel frequency. ACLR is a basic measurement which is defined from the initial edition of the 3GPP but recently additional requirements have been defined to base station classes like as Macro cell, Micro cell, Pico cell, and Femto cell, as well as carrier configurations like as single carrier, multi-carrier, and non-contiguous carrier aggregation. Cumulative ACLR (CACLR) is a new measurement item for tests of non-contiguous carrier aggregation signals added by 3GPP Release 11. This application note organizes the complex measurement conditions and methods.

## ACLR/CACLR Basic Definitions and Measurement Procedures

ACLR is defined in section 6.6.2 of 3GPP TS36.141. There are two indexes of ACLR: the absolute value of the upper limit of the adjacent channel average power, and the relative value referenced to the carrier average power; both values must be satisfied.

Calculation of the average power of each channel uses a standard filter; a square filter defined in Table 1 is used for LTE (E-UTRA) adjacent channels, and an RRC filter is used for W-CDMA (UTRA).

*Table 1. Filter bandwidth applied to LTE channel*

Channel bandwidth (BW <sub>channel</sub> )	1.4 MHz	3 MHz	5 MHz	10 MHz	15 MHz	20 MHz
Number of resource blocks (N <sub>RB</sub> )	6	15	25	50	75	100
Filter bandwidth (BW <sub>config</sub> )	1.095 MHz	2.715 MHz	4.515 MHz	9.015 MHz	13.515 MHz	18.015 MHz

Generally, ACLR is measured using the following procedure:

1. Connect one end of an RF cable to the base station antenna connector and the other end to a signal analyzer.
2. Set the signal analyzer to match the test conditions. Insert an external attenuator to prevent input of an over-voltage damaging the signal analyzer and set an appropriate input level.
3. Set the base station output signal to E-TM1.1 and output the base station maximum power defined by the base station vendor.  
When using a multi-carrier signal, ensure that the average power is equal for each antenna and that the total is the rated overall output. Additionally, the Cell ID number used for each antenna E-TM signal is determined sequentially with the lowest carrier as 1 and Nth carrier Cell ID as N.
4. Set the base station signal to the measured frequency.
5. Measure the ACLR in accordance with the carrier distribution method.  
Measure both the ACLR and CACLR for base stations that support non-contiguous carrier aggregation.
6. Set the base station output signal and the signal analyzer frequency according to the remaining test conditions and repeat steps 5 and 6 over.  
The tested frequencies are the high, medium and low frequencies of the base station operating bands as well as the high, medium and low channels in each operation band.
7. Repeat the same procedure from step 2 to 6 using the E-TM1.2 test model.

Table 2 shows the test requirements for the 3GPP-defined ACLR and CACLR tests.

*Table 2. ACLR/CACLR Test requirement summary*

Measurement	Base Station Type	Upper Limit
Ratio of Carrier Average Power to Adjacent Channel Leakage Power	N/A	44.2 dB
Absolute Value of Adjacent Channel Average Power	Category A, Wide Area BS	-13 dBm/MHz
	Category B, Wide Area BS	-15 dBm/MHz
	Medium Range BS	-25 dBm/MHz
	Local Area BS	-32 dBm/MHz
	Home BS	-50 dBm/MHz <sup>Note</sup>

*Note:* Only absolute ACLR values are defined for Home BS; absolute CACLR values are not defined.

## Carrier Distribution Methods and ACLR/CACLR

### Single Carrier ACLR

In the case of single carrier, the carrier average power and the average powers of the adjacent channels above and below that carrier are measured. LTR (E-UTRA) and W-CDMA (UTRA) channels adjacent to the carrier are both defined in Figs. 1 and 2, respectively, with reference to 3GPP TS34.121 Table 6.6.2-1 (paired spectrum). Measurement is performed by setting the offset frequency for the W-CDMA band) as in Table 6.6.2-2.

The signals used in the following figures are defined below.

$BW_{\text{channel}}$	Any of 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz LTE carrier bandwidths
C	Average carrier power. When there are several carriers to measure, lower carriers are denoted as and upper carriers are denoted as $C_U$ .
L1	Average power of channel adjacent to lower side of carrier
L2	Average power of second channel adjacent to lower side of carrier
U1	Average power of channel adjacent to upper side of carrier
U2	Average power of second channel adjacent to upper side of carrier

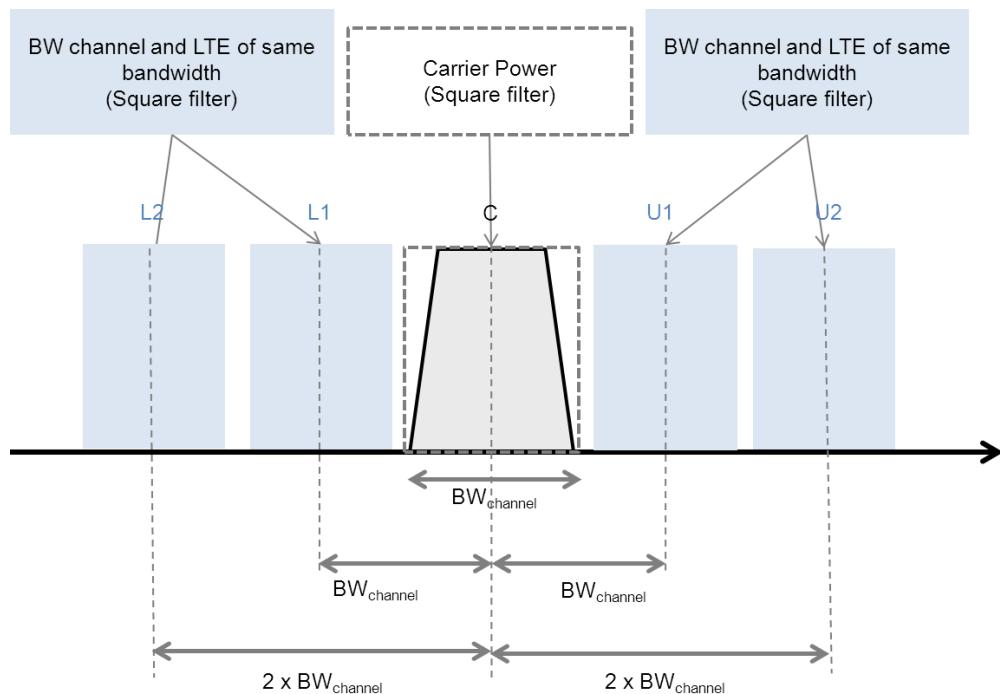
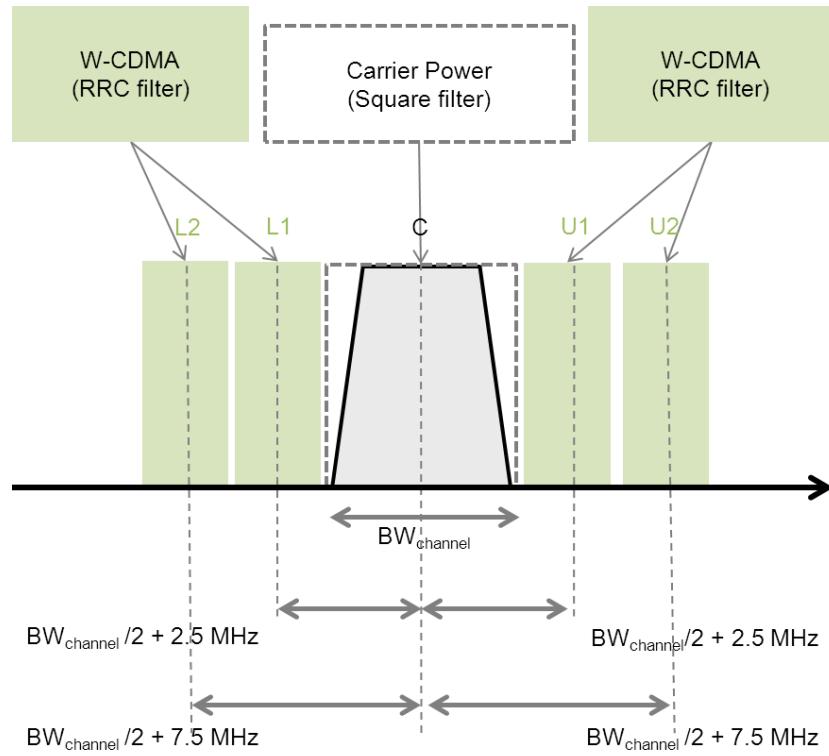


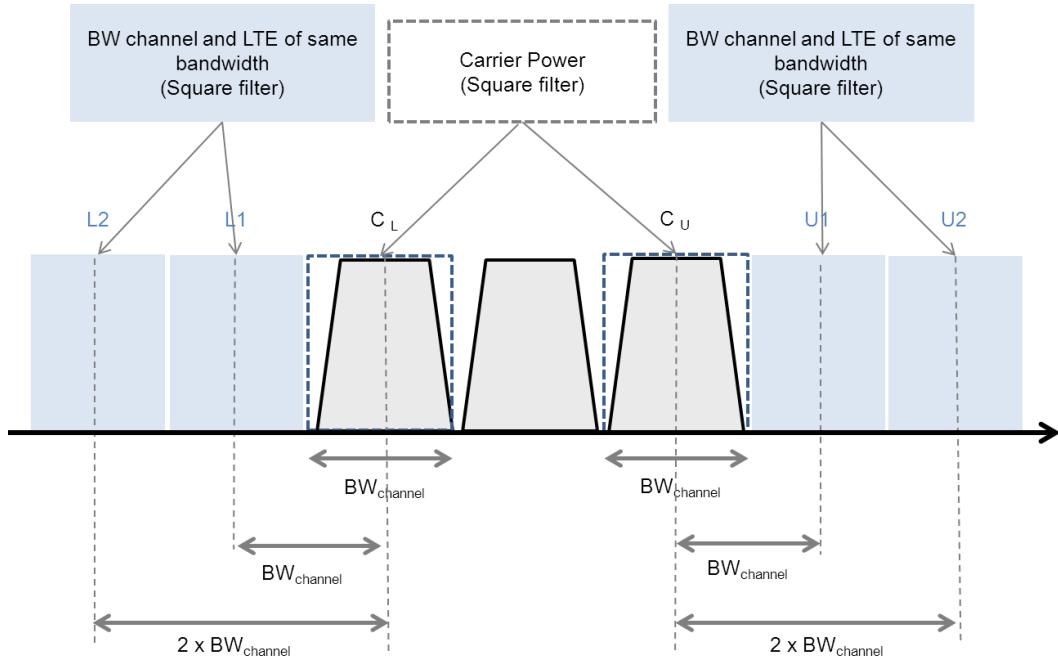
Fig. 1. Single carrier ACLR (LTE adjacent channel)



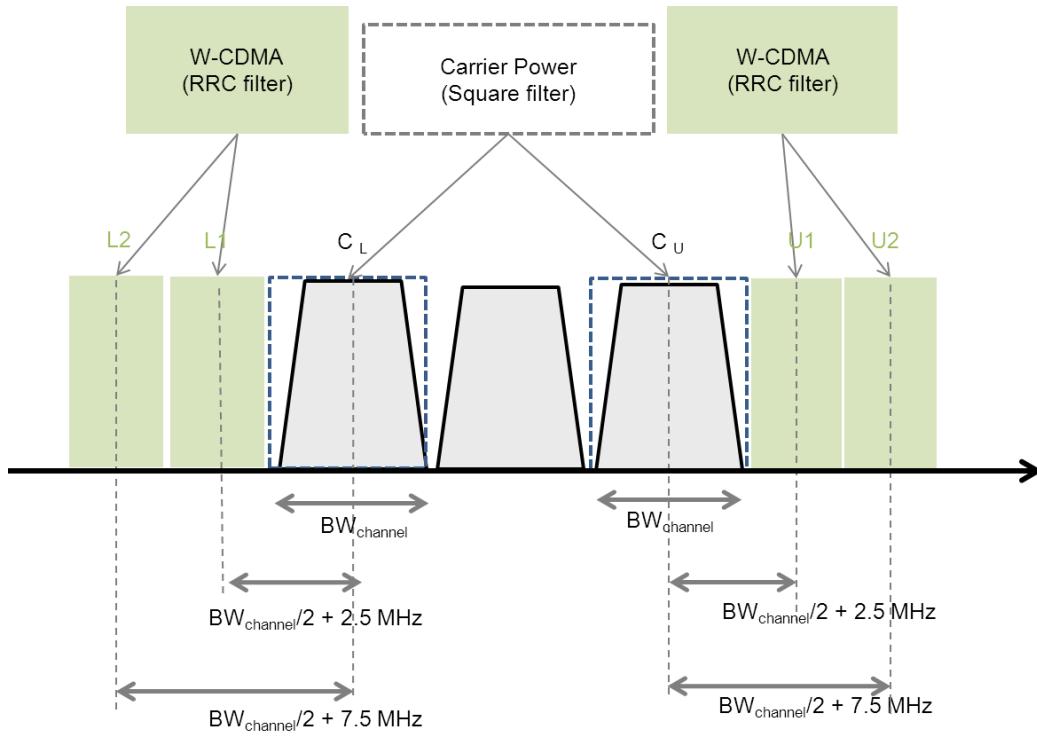
*Fig. 2. Single carrier ACLR (W-CDMA adjacent channel)*

### Multi-carrier ACLR

In the case of multi-carriers, the average power at the center frequency of the carrier  $C_L$  on the lowest side of the multiple carriers and the adjacent channels ( $L_1, L_2$ ) on the lower side of that carrier are measured along with the average power at the center frequency of the carrier  $C_U$  on the uppermost side and the adjacent channels ( $U_1, U_2$ ) on the upper side of that carrier. When determining the power ratio,  $C_L$  is referenced to  $L_1$  or  $L_2$ , and  $C_U$  is referenced to  $U_1$  or  $U_2$ . Figs 3 and 4 show the case when the channels adjacent to the carriers are LTE and W-CDMA, respectively, with reference to 3GPP TS34.121 Table 6.6.2-1 (paired spectrum). Measurement is performed by matching the frequency offsets for the W-CDMA bands as in Table 6.6.2-2.



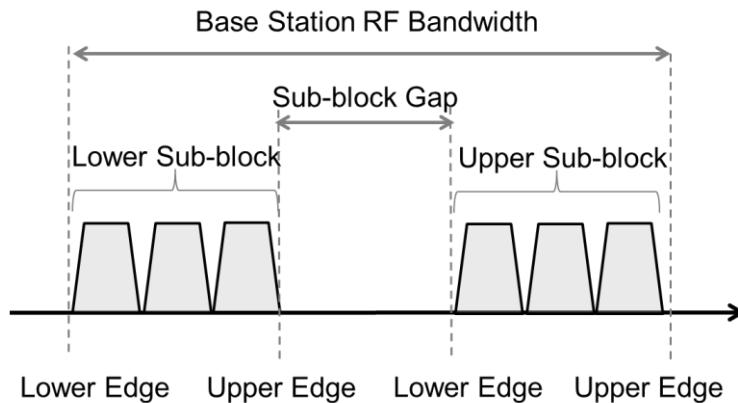
*Fig. 3. Multi-carrier ACLR (LTE adjacent channel)*



*Fig. 4. Multi-carrier ACLR (W-CDMA adjacent channels)*

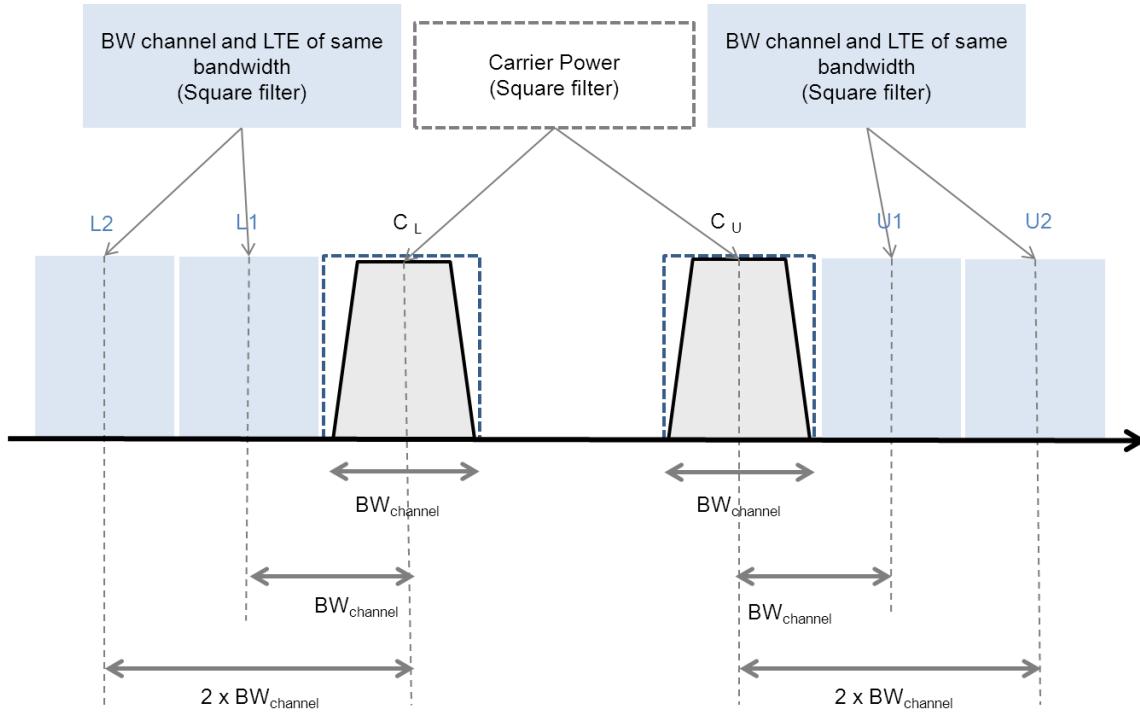
#### *Non-contiguous Carrier Aggregation ACLR*

Release 11 of 3GPP TS36.141 adds a new measurement item when several carriers are aggregated non-contiguously. In 3GPP TS36.141, a group of contiguously aggregated carriers is called a sub-block and the gap between two sub-blocks is called the sub-block gap (Fig. 5). The space between the lower edge of the sub-block at the lowest frequency and the higher edge of the sub-block at the highest frequency is called the RF Bandwidth.

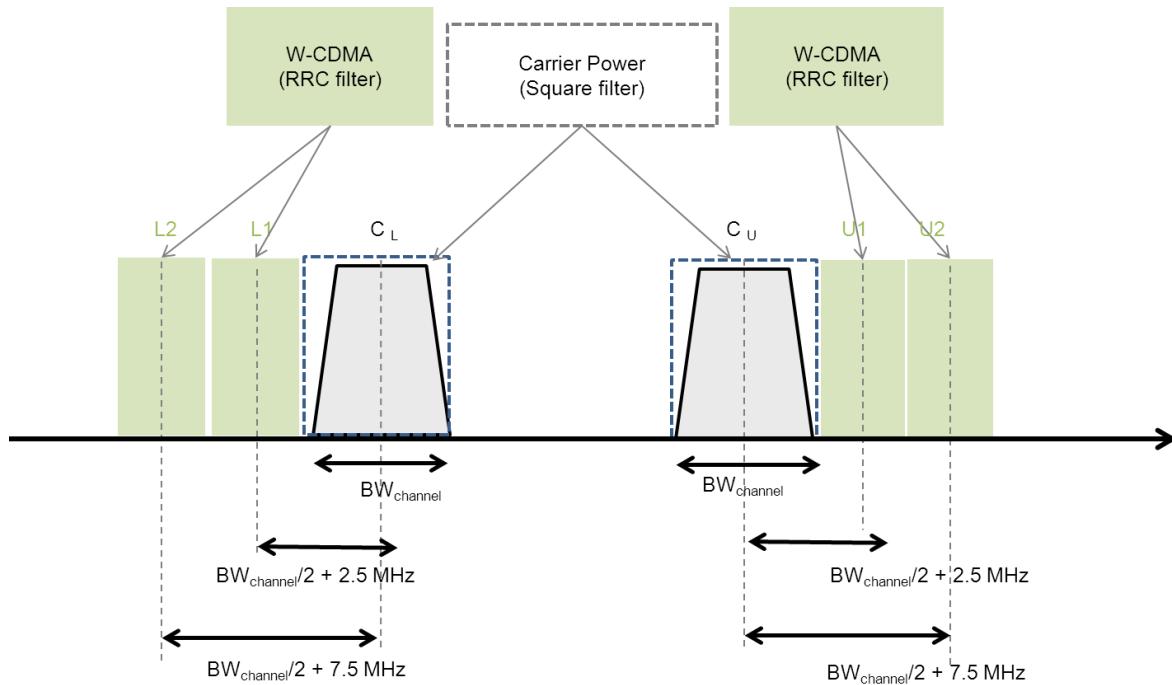


*Fig. 5. Non-contiguous carrier aggregation sub-blocks and gap*

When the carriers are aggregated non-contiguously, the adjacent channels on the outside of the RF Bandwidth and channels adjacent to the sub-blocks within the sub-block gap are measured. Leakage power outside the RF Bandwidth is measured at the adjacent channels ( $L_1$ ,  $L_2$ ) outside the lowest carrier ( $C_L$ ) and at the adjacent channels ( $U_1$ ,  $U_2$ ) outside the uppermost carrier ( $C_U$ ) (Figs. 6 and 7). When determining the power ratio,  $C_L$  is referenced to  $L_1$  or  $L_2$ , and  $C_U$  is referenced to  $U_1$  or  $U_2$ .



*Fig. 6. Non-contiguous carrier aggregation ACLR (outside sub-block gap, and LTE adjacent channels)*



*Fig. 7. Non-contiguous carrier aggregation ACLR (outside sub-block gap, and W-CDMA adjacent channels)*

Either ACLR or CACLR, or both ACLR and CACLR are measured inside the sub-block gap ( $W_{gap}$ ). At non-contiguous aggregation, ACLR measures the average power of the carriers adjacent to both sides of the sub-block gap and the average power of the channels at the inside of the sub-block gap for each of the sub-block gap upper and lower frequencies (Figs. 8 and 9). When determining the power ratio,  $C_L$  is referenced to L1 or L2, and  $C_U$  is referenced to U1 or U2.

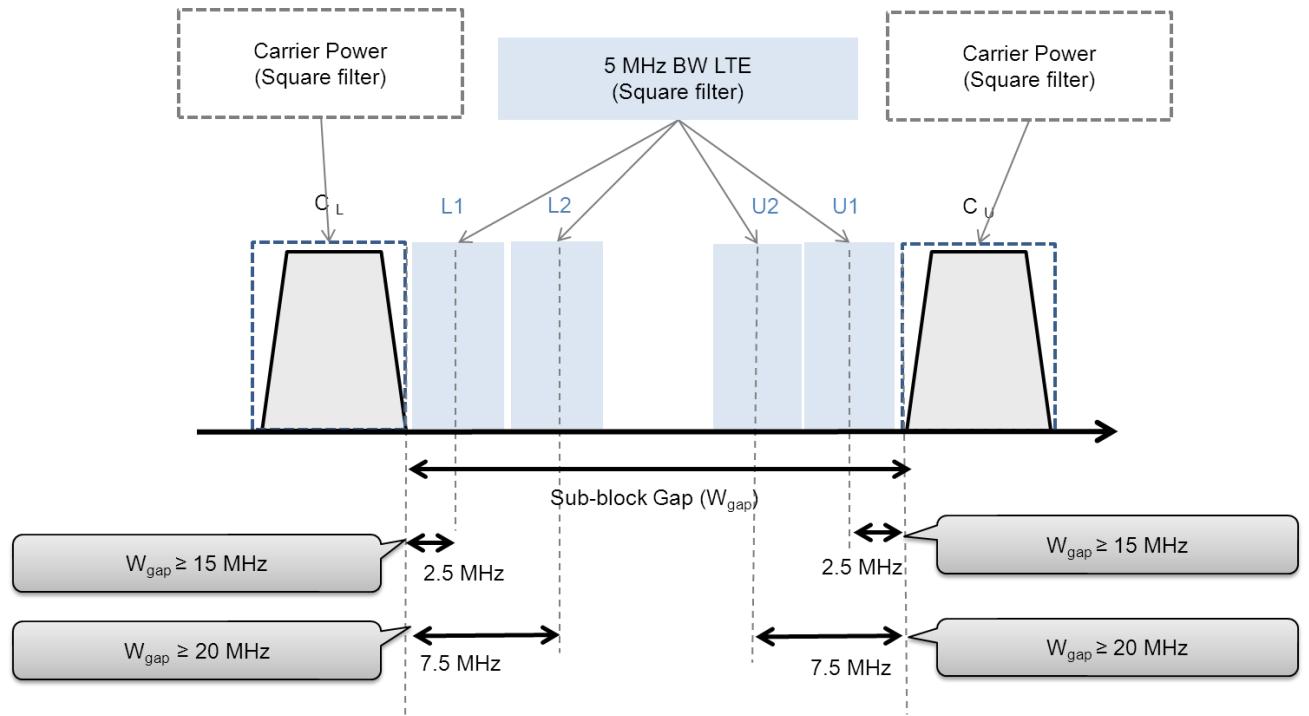


Fig. 8. Non-contiguous carrier aggregation ACLR (sub-block gap, and LTE adjacent channels)

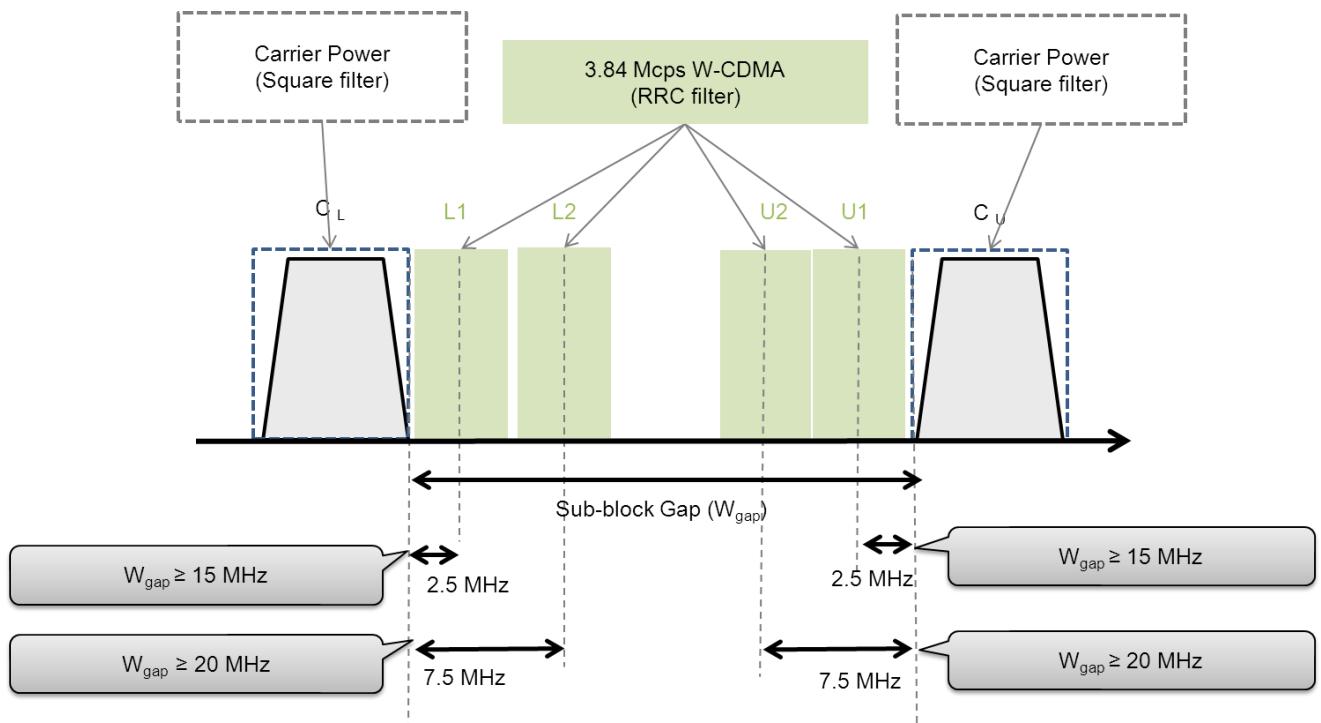


Fig. 9. Non-contiguous carrier aggregation ACLR (sub-block gap and W-CDMA adjacent channels)

## Non-contiguous Carrier Aggregation CACLR

In the case of non-contiguous carrier aggregation, CACLR measures the sum of the average powers of carriers adjacent to both sides of the sub-block gap ( $C_L + C_U$ ) and average power of the channels in the sub-block gap adjacent to this (Figs. 10 and 11). When determining the power ratio, the sum of the carrier powers ( $C_L + C_U$ ) is referenced to each of L1, L2, U1, and U2.

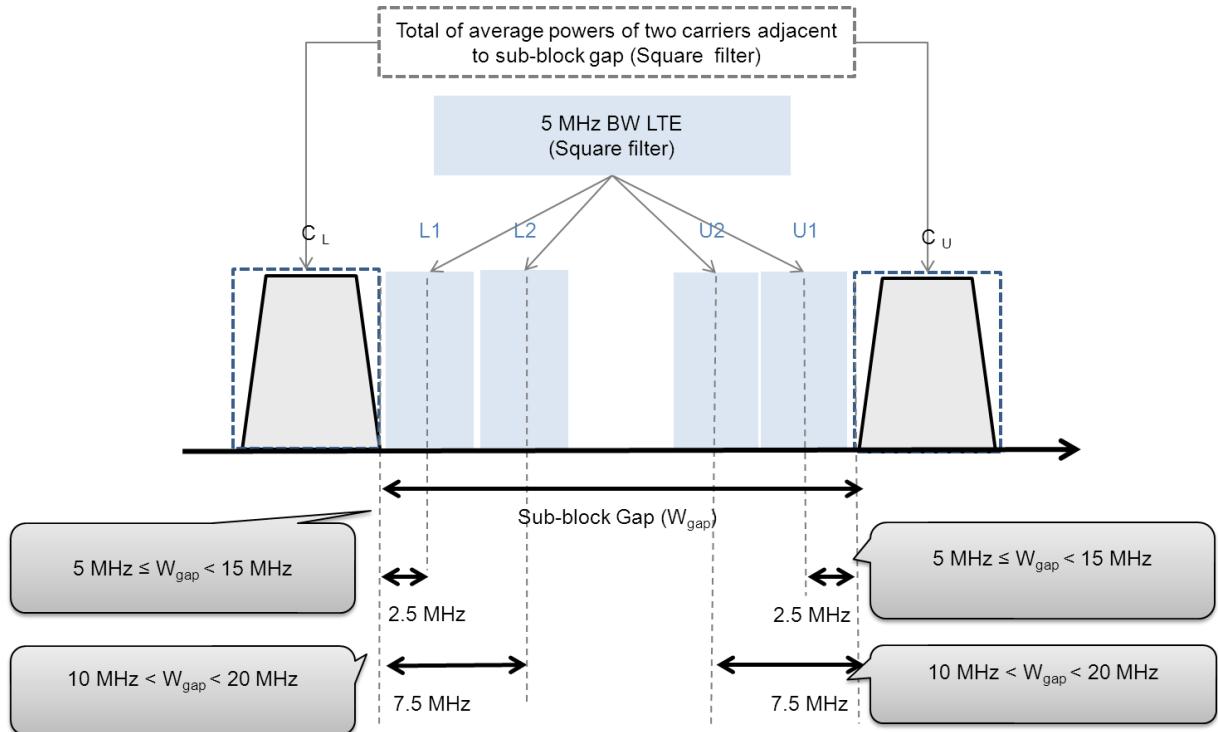


Fig. 10. Non-contiguous carrier aggregation CACLR (sub-block gap and LTE adjacent channels)

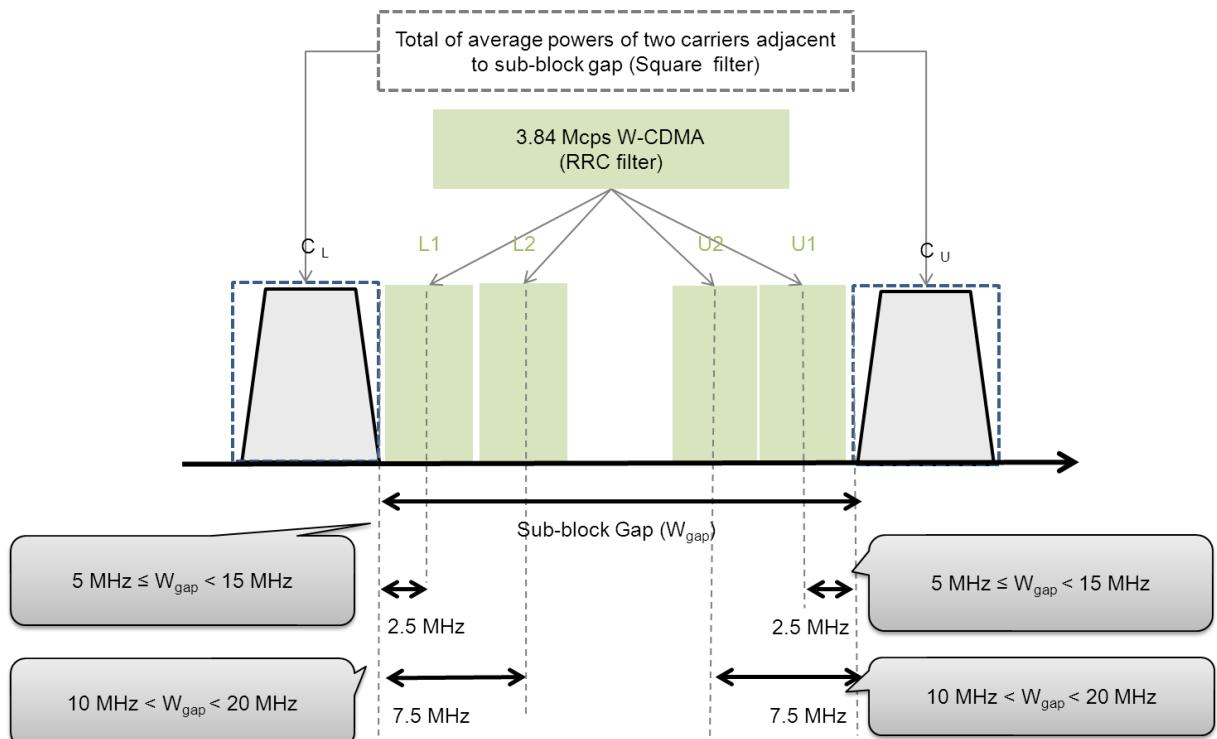


Fig. 11. Non-contiguous carrier aggregation CACLR (sub-block gap and W-CDMA adjacent channels)

Table 3 lists the ACLR and CACLR applications found from 3GPP Table 6.6.2-3 and Table 6.6.2-5 for the non-contiguous spectrum.

*Table 3. Non-contiguous Spectrum ACLR and CACLR Applications (sub-block gap)*

Frequency offset from sub-block gap	ACLR		CACLR	
	2.5 MHz	7.5 MHz	2.5 MHz	7.5 MHz
$5 \text{ MHz} \leq W_{\text{gap}} \leq 10 \text{ MHz}$	n/a	n/a	Applicable	n/a
$10 \text{ MHz} < W_{\text{gap}} < 15 \text{ MHz}$	n/a	n/a	Applicable	Applicable
$15 \text{ MHz} \leq W_{\text{gap}} < 20 \text{ MHz}$	Applicable	n/a	n/a	Applicable
$W_{\text{gap}} \geq 20 \text{ MHz}$	Applicable	Applicable	n/a	n/a

## Measurement Examples using Spectrum Analyzer

This section explains an example of measuring the ACLR and CACLR of a non-contiguous carrier aggregation using the spectrum analysis function of the Anritsu MS269xA series of signal analyzers. However, note that the displayed measurement results are just examples and they are not guaranteed values.

### Non-contiguous Carrier Aggregation CACLR

First, an example of CACLR measurement inside the sub-block gap is explained.

This example uses two LTE FDD 5-MHz bandwidth carriers with a sub-block gap of 10 MHz; the adjacent channels are 3.84 Mcps W-CDMA.

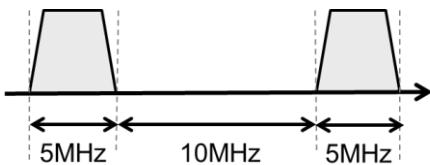


Fig. 12. Non-contiguous carrier aggregation measurement example (1)

#### [Procedure]

1. Press [Application Switch] and select [Spectrum Analyzer].
2. Press [Preset] -> [F1] Preset.
3. Press [Frequency] and set the center frequency (e.g. 2 GHz).
4. Press [Span] and set the span to 30 MHz.
5. Press [Measure] -> [F1] ACP and set the ACLR measurement function to ON.
6. In the ACP function menu, press [F2] ACP Reference -> [F2] Carrier Total so that the reference power is the total of the adjacent carriers in the sub-block gap.
7. Press the back button to return to the ACP function menu.
8. In the ACP function menu, press [F3] In Band Setup -> [F1] Carrier Number and set 2.
9. In the In-band Setup function menu, press [F3] Carrier Spacing and set 15 MHz.  
The value set by this parameter is the total of half the bandwidth of the carrier on the lower side ( $5 \text{ MHz} \div 2 = 2.5 \text{ MHz}$  in this example) plus the sub-block gap (10 MHz) plus half the bandwidth of the carrier on the upper side ( $5 \text{ MHz} \div 2 = 2.5 \text{ MHz}$  in this example), or  $2.5 + 10 + 2.5 = 15 \text{ MHz}$ .
10. In the In-band Setup function menu, press [F4] Carrier BW and set 5 MHz.
11. In the In-band Setup function menu, press [F7] Filter Type -> [F1] Rect.
12. Press the back button twice to return to the ACP function menu.
13. In the ACP function menu, press [F4] Offset Setup.
14. In the Offset Setup function menu, press [F1] Ch BW and set 3.84 MHz (default value).
15. In the Offset Setup function menu, press [F7] Filter Type -> [F1] Root Nyquist (default value).
16. In the Offset Setup function menu, press [F8] Roll-off Factor and set 0.22 (default value).
17. Press the back button to return to the Offset Setup function menu.
18. Press the next page button to display the second page of the Offset Setup function menu.
19. At page 2 of the Offset Setup function menu, press [F2] Offset-1 and set -5 MHz. Since this Offset value is a negative value, an offset section can be set in the sub-block gap, or in other words between the two carriers. The value of this parameter setting is the total of half the carrier bandwidth ( $5 \text{ MHz} \div 2 = 2.5 \text{ MHz}$ ) plus the value of the 3GPP-recommended BS adjacent channel center frequency offset value.
20. In this example, because the next adjacent channel is not measured, at page 2 of the Offset Setup function menu, set [F3] Offset-2 to Off.
21. Press the back button to return to the ACP function menu.
22. In the ACP function menu, press [F5] Power Result Type -> [F3] All.
23. Press [Trace] -> [F3] Storage Mode -> [F1] Lin Average.
24. In the Trace function menu, press [F8] Detection and set RMS.
25. Press [Time/Sweep] -> [F4] Trace Points and set 1001.
26. Press [Marker] -> [F5] Off to not display the marker.

Fig.13 shows one result example by the above settings. The function menu displays the ACP Reference function menu to clarify the differences between CACLR and ACLR. In this example, the L1 CACLR is 71.12 dB, and the U1 CACLR is 71.03 dB.

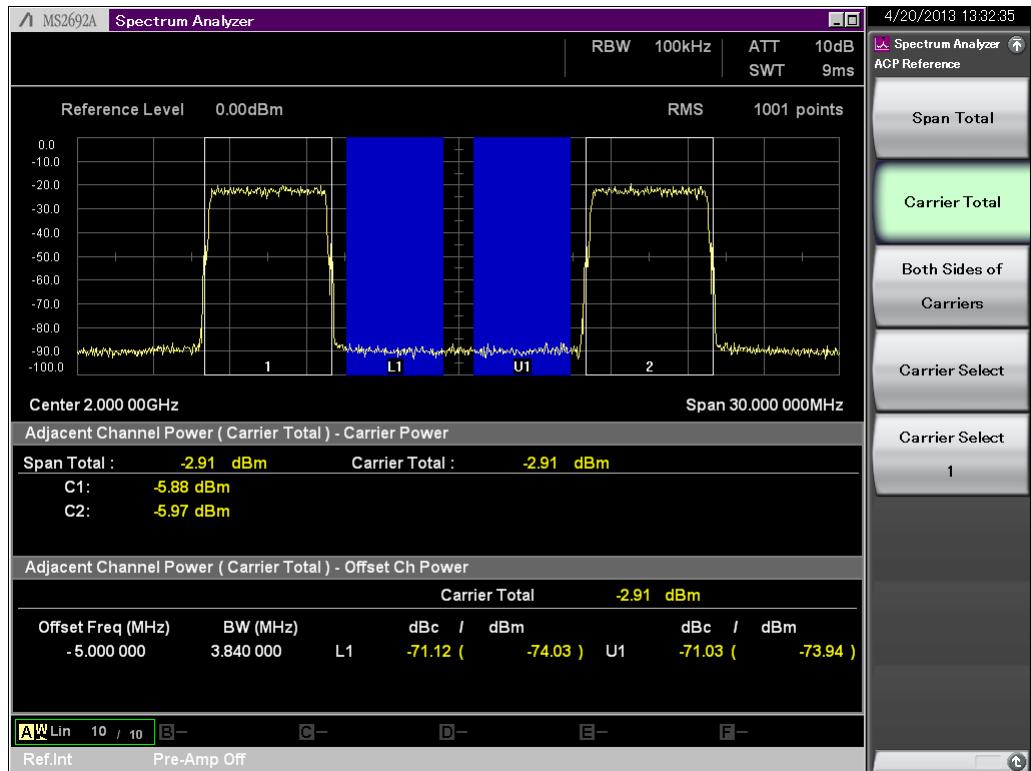


Fig. 13. Non-contiguous spectrum CACLR (sub-block gap) measurement example

## Non-contiguous Carrier Aggregation ACLR (Inside Sub-block Gap)

Next, an example of ACLR measurement inside the sub-block gap is explained.

This example uses two LTE FDD 5-MHz bandwidth carriers with a sub-block gap of 15 MHz; the adjacent channels are 3.84 Mcps W-CDMA. The following procedure is a continuation of the CACLR measurement.

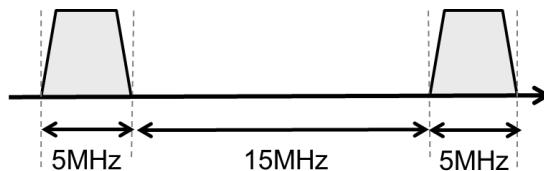


Fig. 14. Non-contiguous carrier aggregation measurement example (2)

### [Procedure]

27. Press [Measure] ->[F1] ACP to display the ACP function menu.
28. In the ACP function menu, press [F2] ACP Reference -> [F3] Both Sides of Carriers.  
When selecting Both Sides of Carriers, the upper side offset references the carrier power of the largest carrier number, and the lower offset references the carrier power of the smallest carrier number.
29. Press the back button to return to the ACP function menu.
30. In the ACP function menu, press [F3] In-band Setup and set [F1] Carrier Number to 2.
31. In the In-band Setup function menu, press [F3] Carrier Spacing and set 20 MHz. The value set by this parameter is the total of half the bandwidth of the carrier on the lower side ( $5 \text{ MHz} \div 2 = 2.5 \text{ MHz}$  in this example) plus the sub-block gap (10 MHz) plus half the bandwidth of the carrier on the upper side ( $5 \text{ MHz} \div 2 = 2.5 \text{ MHz}$  in this example), or  $2.5 + 15 + 2.5 = 20 \text{ MHz}$ .
32. Press the back button two times to return to the ACP function menu.
33. In the ACP function menu, press [F4] Offset Setup.
34. Press the next page button to display the second page of the Offset Setup function menu.
35. At page 2 of the Offset Setup function menu, press [F2] Offset-1 and set -5 MHz.

Fig.15 shows one result example by the above settings. In this example, the ACLR of L1 is 68.31 dB and the ACLR of U1 is 67.64 dB.



Fig. 15. Non-contiguous spectrum ACLR (sub-block gap) measurement example

## Summary

This application note describes ACLR and CACLR measurement methods for various carrier configurations output from mobile base stations. The latter half explains some measurement examples using the spectrum analysis function of the Anritsu MS269xA series of spectrum analyzers. The spectrum analysis function features universal applicability without restrictions, such as carrier bandwidth and number.

Anritsu offers ACLR measurement solutions in addition to this. The signal analyzer function using FFT has some restrictions such as a narrower maximum analysis bandwidth compared to the spectrum analyzer but features high-speed measurement with the same operation. Moreover, the MX269020A LTE Downlink Measurement Software supports ACLR measurement, as well as EVM, etc., modulation analysis.

Anritsu provides measurement solutions meeting all customers' measurement conditions. Please visit Anritsu Web site.

### Related Application Notes

- [MS269xA signal Analyzer \(Ultra-High-Speed ACLR Measurement\)](#) No.MS269xA-E-F-4
- [LTE-Advanced Carrier Aggregation Measurement](#) No. MX269020A/MX370108A-E-F-2

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