Benchmarking PXB Baseband Generator and Channel Emulator Fading Performance

Application Note

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1.0 Introduction

RF faders (channel emulators) allow engineers to comprehensively evaluate wireless communication systems by predicting their performance in response to real-world conditions. The Agilent N5106A PXB baseband generator and channel emulator is a comprehensive diagnostic toolset for designing and verifying wireless signal processing devices. Unlike dedicated faders, the PXB combines real-time fading with multichannel baseband generation and signal capture in a single, multipurpose instrument.

While the benefits of such a combination are numerous, it is reasonable to question if the fading provided by the PXB rivals that of a dedicated RF fader. This application note is intended to specifically address that question by benchmarking the fading performance of the Agilent PXB against two well-known RF fading solutions: the Spirent SR5500 Wireless Channel Emulator and the Elektrobit Propsim C8 multichannel emulator. Test results will show that the PXB has fading performance comparable to that of the Spirent SR5500 and Elektrobit C8, moreover, it fully satisfies the performance specification in 3GPP TS 34.121-1 v8.6.0. [1]

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2.0 Typical Fading Applications

Fading is relevant throughout the entire product development cycle, from baseband algorithm research and design, all the way through to functional and conformance testing. During preliminary chip design, it is used to prove that the initial breadboard design actually works as simulations predicted. At this early stage, fading essentially tests the robustness of the design's error correction. In application-specific integrated circuit (ASIC) development, fading helps verify that wafers are manufactured correctly. During integration, when the RF and baseband sections are mated, RF fading helps ensure there are no surprise interactions between the sections. During validation or pre-conformance test, it allows the engineer to be sure the device will pass the specific tests called out in the standard—before any money has been invested in having it certified by a commercial test facility. During conformance test on the finished device, fading is used to ensure the device passes all standard requirements. Fading is even used during the post release phase, where the unit is stress tested to determine the true performance limits—a process that helps the engineer determine whether or not the device can be improved with post release firmware upgrades.

3.0 Solutions

Three solutions that provide fading include the Spirent SR5500, Elektrobit Propsim C8 and Agilent N5106A PXB. The first two are dedicated solely to fading, while the PXB offers fading, multichannel baseband generation and signal capture.

RF faders

All faders either downconvert to baseband and then fade, or fade baseband directly. Downconversion is required because no digital processor is available today that can handle a 6 GHz input sample rate.

Dedicated RF faders like the SR5500 or Propsim C8 perform RF to RF fading with a fairly simple up and down conversion using a single local oscillator (LO). As a result, the input signal power has to be fairly high, and the insertion loss associated with having the fader in the path can only be compensated with external amplification. This translates into extra power being required at the transmitter. Additionally, since broadband amplifiers are difficult to obtain, RF faders tend to offer a limited range of power and banded frequency ranges.

PXB baseband generator and channel emulator

The N5106A PXB provides fading of internally generated signals, as well as fading of external RF inputs coming from a user device. To fade external RF signals, the PXB requires an Agilent MXA signal analyzer to function as an external downconverter. After the downconverted signal is faded inside the PXB, it is upconverted back to RF using an Agilent ESG or MXG signal generator. In this setup, the PXB functions as a system controller for the external converters, calibrating and driving them seamlessly as though they were a single unit.

One advantage of using the MXA as a downconverter is that the PXB can take advantage of its preamplifier to accept lower level input signals. And, because the output power of the MXG is not a direct function of the input power, there can actually be an insertion gain, rather than a loss. As a result, it takes less external amplification to get the system up and running.

Furthermore, since all the summing and noise addition is done digitally, and the RF converters are metrology grade, the power ratios between channels in the PXB are very precise. The PXB also boasts an internal self-calibration routine, meaning that the power calibration with the PXB in the system takes seconds, instead of minutes, for external RF summing.

Another key benefit of the PXB is that it stretches across the R&D lifecycle, enabling engineers to address their need for baseband generation plus fading early in the design process, as well as RF fading for later stages of design. In early R&D stages, such as for receiver development and integration, engineers require both signal generation and channel emulation because the transmitter has not yet been built. However, in later R&D stages, such as design validation and pre-conformance, engineers need signal generation less because they will stimulate their receiver with their own transmitter.

Like other RF faders, the PXB downconverts external RF inputs to baseband before fading is applied. Using a signal analyzer/signal source, the PXB's up/downconversion offers better noise floor performance than the up/downconversion typically offered by other RF faders. Consequently, the PXB will yield better throughput results at low signal-to-noise ratios. This fact is evident in some of the test results shown in the Multipath Fading Test Section in this application note.

For example, suppose the signal power of DPCH_Ec is E, the internally generated noise power is n and the deliberately added noise power, Additive White Gaussian Noise (AWGN) power, is N.

Then, the actual $\frac{DPCH\_E_c}{I_{or}}$ is E/(n + N). If n is large relative to N, it will influence the block error (BLER) test results and that influence will be more profound in cases when $\frac{DPCH\_E_c}{I_{or}}$ is low.

4.0 Benchmarking Test Methodology

For the purpose of this application note, the BLER was selected as the benchmark test performance index. The BLER test was performed according to Sections 7.2 and 7.3 (static propagation and multipath fading, respectively) of the 3GPP TS 34.121-1 v8.6.0 specification. W-CDMA was used as the communication standard for the test.

5.0 Test Platform: Setup and Calibration

The following section details how to set up the test platforms of the three channel emulators used in the BLER tests in this application note. Information regarding how to calibrate the test platforms to make the test more accurate is also provided.

N5106A PXB baseband generator and channel emulator

As depicted in Figure 5-1, the N5106A test system is comprised of the N5106A PXB, MXA signal analyzer and the ESG signal generator. These three instruments function as a single element controlled by the N5106A PXB.

The faded signal output from the ESG to the test UE has an additional attenuation that comes from the cables and the circulator between them. This attenuation is measured and must be compensated for in the test. The measured attenuation is 3.7 dB.

The test UE utilized for the benchmark test in this application note is the AirCard 875 wireless data card from Sierra Wireless Incorporated.

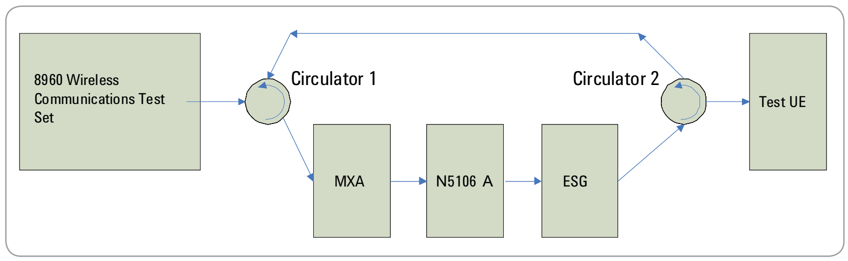

Figure 5-1. The N5106A PXB test platform system diagram

SR5500 wireless channel emulator

A system diagram of the SR5500 test platform is shown in Figure 5-2. Because this particular SR5500 did not include an AWGN option, an additional ESG signal generator and power combiner was used to add AWGN to its faded signal output. The attenuation of the cables, power combiner and circulator were measured and compensated. The measured attenuation is 8.5 dB.

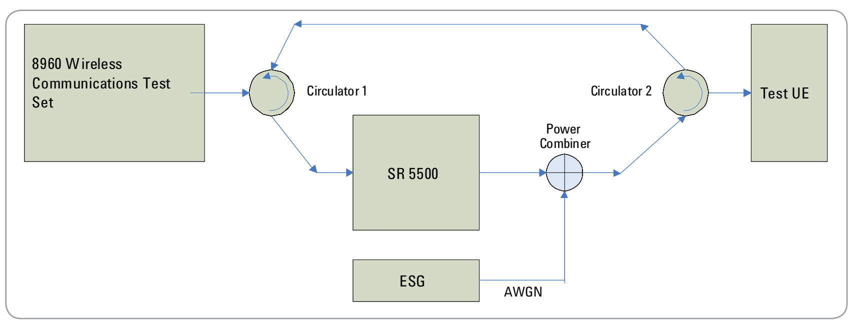

Figure 5-2. The SR5500 test platform system diagram

Propsim C8 multichannel emulator

A system diagram of the C8 test setup is shown in Figure 5-3. Because this particular C8 did not include an AWGN option, an additional ESG signal generator and power combiner were used to add AWGN to its faded signal output. The attenuation of the cables, power combiner and circulator were measured and compensated. The measured attenuation is 8.5 dB.

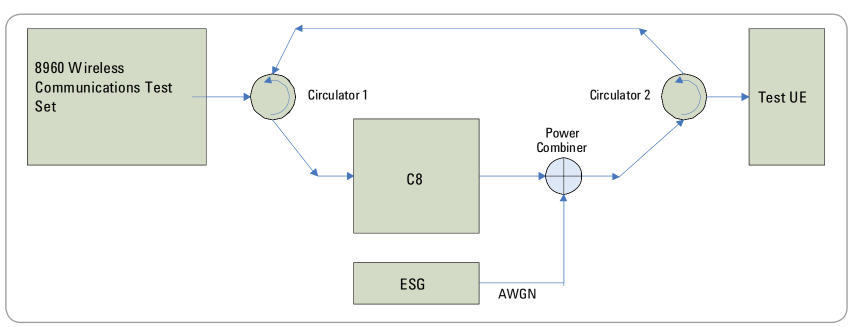

Figure 5-3. The C8 test platform system diagram

6.0 Test Results

The BLER tests were performed according to Sections 7.2 and 7.3 of the 3GPP TS 34.121-1 v8.6.0 specification. Additional test points were added to each test to ensure at least three test result points. The test requirements and results for all tests are provided below.

For low-speed test cases, the test time is long (about 8200 blocks or 164 sec). The test times were shortened to complete all test cases in a reasonable amount of time. For cases where the expected BLER was above 1 percent, the number of blocks was set to 1000. Where the expected BLER was 0.1~1 percent, the number of blocks was set to 2000. Lastly, for test cases where the expected BLER was below 0.1 percent, the number of blocks was set to 4000. Although the test time was shortened, the test results are still valid for comparison purposes. In a few instances, the BLER of the different channel emulators were not close to one other. Nevertheless, in each instance, the results still satisfied the standard specification.

Note that the Agilent N5115B Baseband Studio for RF fading was also used in the BLER benchmark tests that were conducted. The test results for this channel emulator have been included below, for comparison.

Static propagation test

Minimum test requirements
The test results for the minimum requirements specified in Tables 7.2.1.1 and 7.2.1.2 in 3GPP TS 34.121-1 v8.6.0 are shown in Table 6-1.

Table 6-1. Test results for the minimum requirements, Test 1-4

Test number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
1	12.2	–17.6	1.00%	1.20%	2.20%	2.25%	–1	NA
		–16.6	0.10%	0.30%	0.35%	0.25%	–1	1%
		–15.6	0.02%	0.00%	0.00%	0.00%	–1	NA
2	64	–13.1	4.35%	5.80%	4.80%	5.23%	–1	10%
		–12.8	0.55%	0.70%	0.40%	0.45%	–1	1%
		–12.5	0.12%	0.15%	0.10%	0.20%	–1	NA
3	144	–9.9	4.85%	3.40%	4.60%	4.40%	–1	10%
		–9.8	0.75%	0.40%	0.35%	0.80%	–1	1%
		–9.7	0.02%	0.00%	0.10%	0.20%	–1	NA
4	384	–5.6	3.27%	3.90%	4.90%	4.40%	–1	10%
		–5.5	0.72%	0.90%	0.50%	0.80%	–1	1%
		–5.4	0.02%	0.00%	0.05%	0.20%	–1	NA

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-1, 6-2, 6-3 and 6-4, respectively.

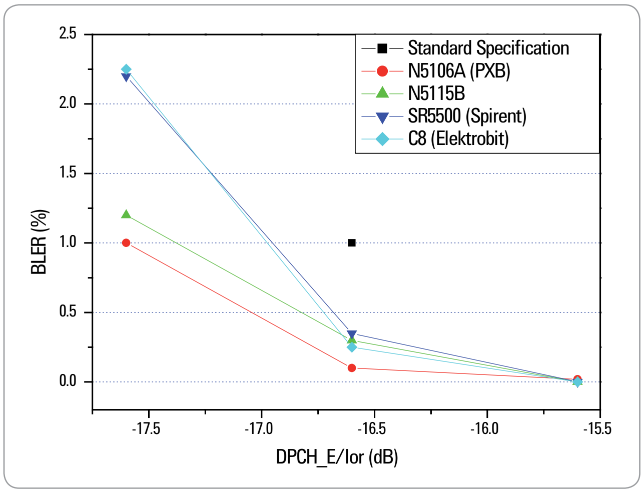

Figure 6-1. BLER versus DPCH_E/Ior curve of Test 1

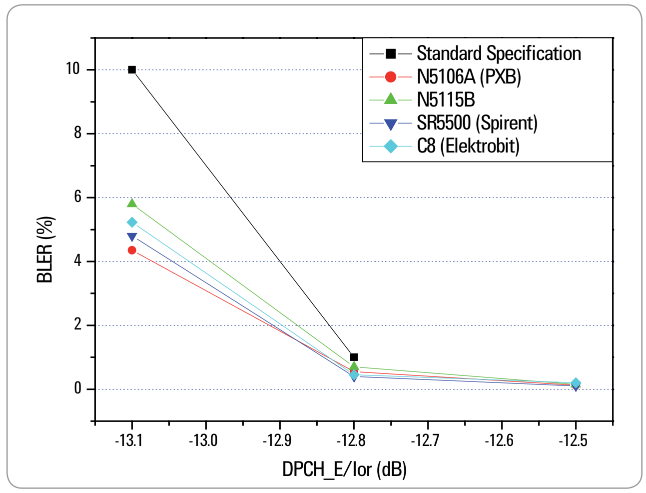

Figure 6-2. BLER versus DPCH_E/Ior curve of Test 2

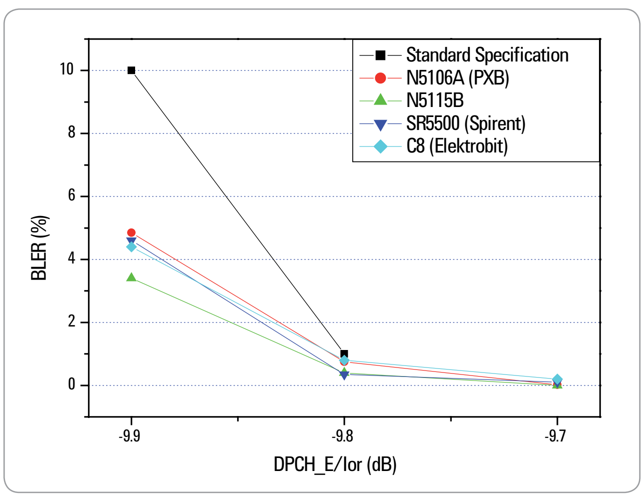

Figure 6-3. BLER versus DPCH_E/Ior curve of Test 3

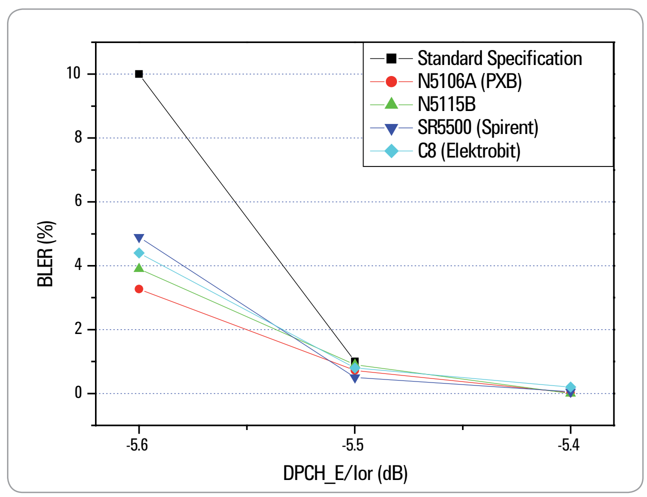

Figure 6-4. BLER versus DPCH_E/Ior curve of Test 4

Test results

The test results for the minimum requirements specified in Tables 7.2.1.3 and 7.2.1.4 in 3GPP TS 34.121-1 v8.6.0 are shown in Table 6-2.

Table 6-2. Test results for the minimum requirements, Test 1-4

Test number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
1	12.2	–17.5	3.60%	2.40%	3.10%	3.70%	–0.7	NA
		–16.5	0.40%	0.50%	0.15%	0.60%	–0.7	1%
		–15.5	0.02%	0.05%	0.00%	0.06%	–0.7	1%
2	64	–13	4.05%	3.00%	2.80%	3.80%	–0.7	10%
		–12.7	0.18%	0.50%	0.30%	0.45%	–0.7	1%
		–12.4	0.02%	0.10%	0.00%	0.20%	–0.7	NA
3	144	–9.8	1.80%	1.60%	2.40%	1.60%	–0.7	10%
		–9.7	0.24%	0.30%	0.40%	0.40%	–0.7	1%
		–9.6	0.06%	0.08%	0.05%	0.15%	–0.7	NA
4	384	–5.5	1%	3%	2.50%	1.20%	–0.7	10%
		–5.4	0.22%	0.30%	0.20%	0.30%	–0.7	1%
		–5.3	0.04%	0.00%	0.05	0.18%	–0.7	NA

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-5, 6-6, 6-7 and 6-8, respectively.

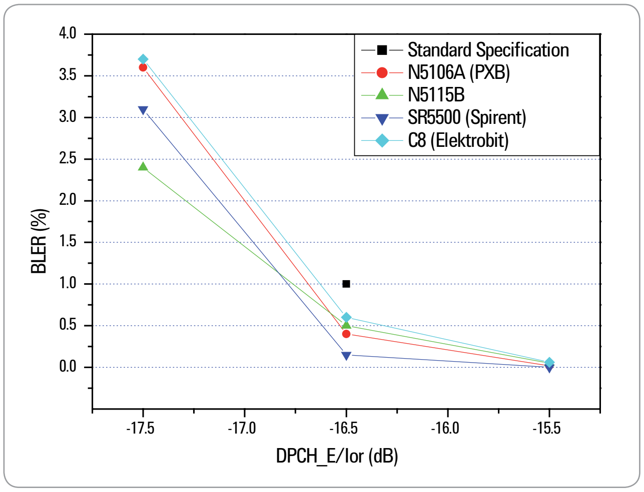

Figure 6-5. BLER versus DPCH_E/Ior curve of Test 1

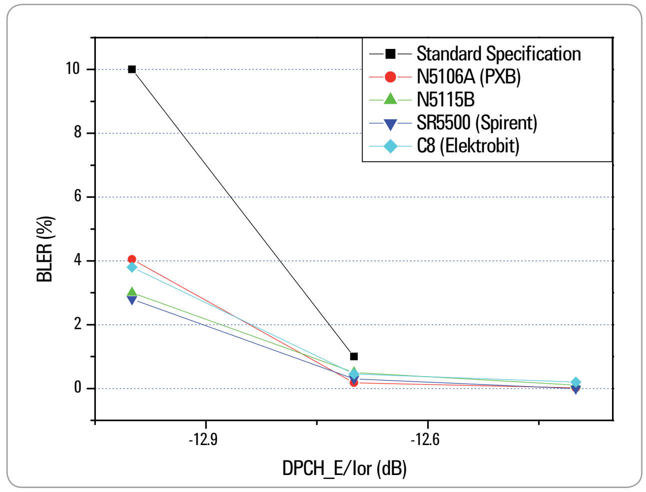

Figure 6-6. BLER versus DPCH_E/Ior curve of Test 2

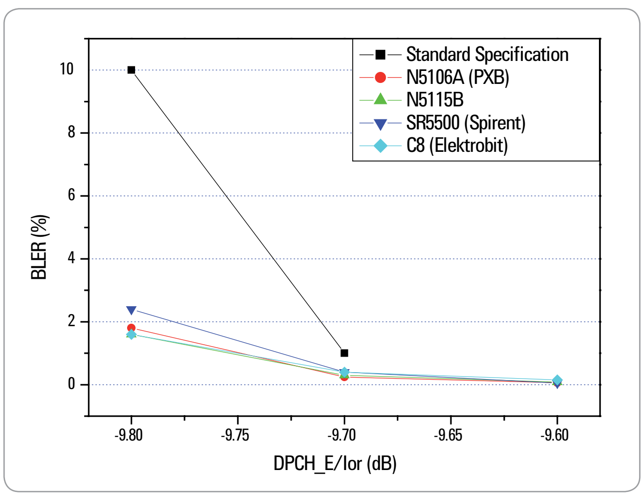

Figure 6-7. BLER versus DPCH_E/Ior curve of Test 3

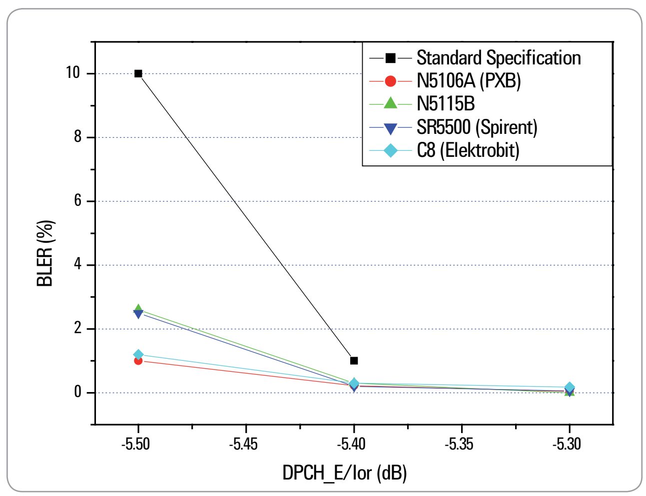

Figure 6-8. BLER versus DPCH_E/Ior curve of Test 4

Multipath fading test

Minimum test requirements
The test results for the minimum requirements for Test 1-4, specified in Tables 7.3.1.1 and 7.3.1.2 in 3GPP TS 34.121-1 v8.6.0, are shown in Table 6-3.

Table 6-3. Test results for the minimum requirements, Test 1-4

Test number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
1	12.2	–17	3.10%	2.12%	1.80%	4.40%	9	NA
		–16	1.40%	1.54%	1.30%	2.20%	9	NA
		–15	0.70%	0.88%	0.90%	0.70%	9	1%
		–13	0.10%	0.15%	0.05%	0.00%	9	NA
2	64	–13.9	9.45%	8.45%	9.10%	9.50%	9	10%
		–12	2.75%	2.27%	2.90%	1.70%	9	10%
		–10	0.82%	0.93%	0.95%	0.10%	9	1%
		–7	0.25%	0.20%	0.10%	0.00%	9	NA
		–6	0.12%	0.08%	0.02%	0.00%	9	NA
3	144	–10.6	7.50%	8.03%	5.70%	9.30%	9	10%
		8.7	2.80%	2.50%	2.50%	3.20%	9	NA
		–6.8	0.80%	0.75%	0.50%	0.30%	9	1%
		–4.9	0.10%	0.13%	0.10%	0.00%	9	NA
		–3	0.05%	0.08%	0.03%	0.00%	9	NA
4	384	–6.3	5.35%	5.20%	6.50%	8.80%	9	10%
		–4.25	3.00%	2.60%	2.60%	2.10%	9	NA
		–2.2	0.75%	0.90%	0.90%	0.30%	9	1%
		–1	0.30%	0.38%	0.45%	0.20%	9	NA

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-9, 6-10, 6-11 and 6-12, respectively.

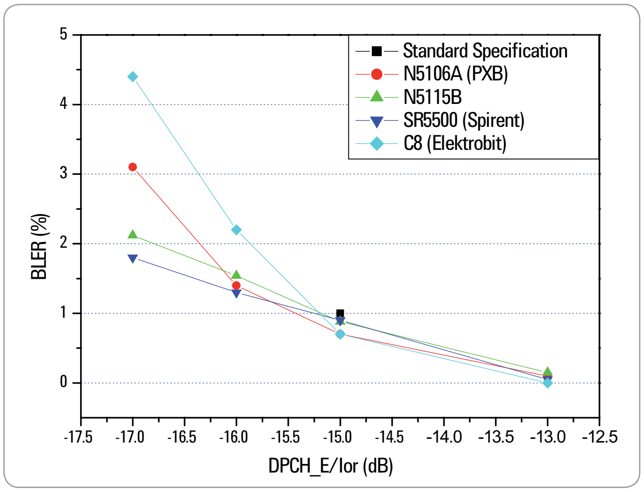

Figure 6-9. BLER versus DPCH_E/Ior curve of Test 1

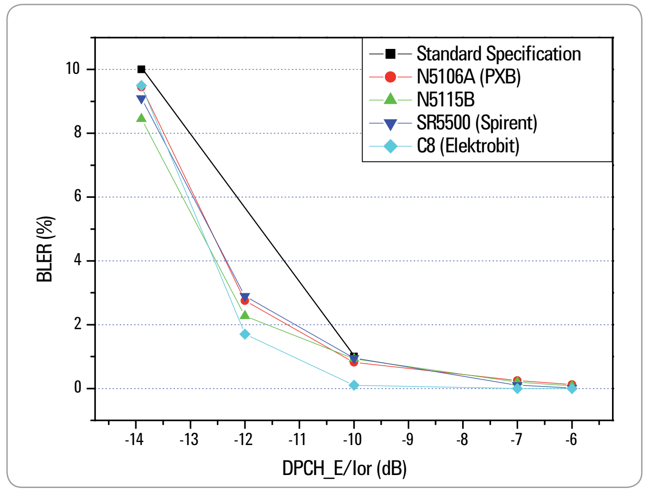

Figure 6-10. BLER versus DPCH_E/Ior curve of Test 2

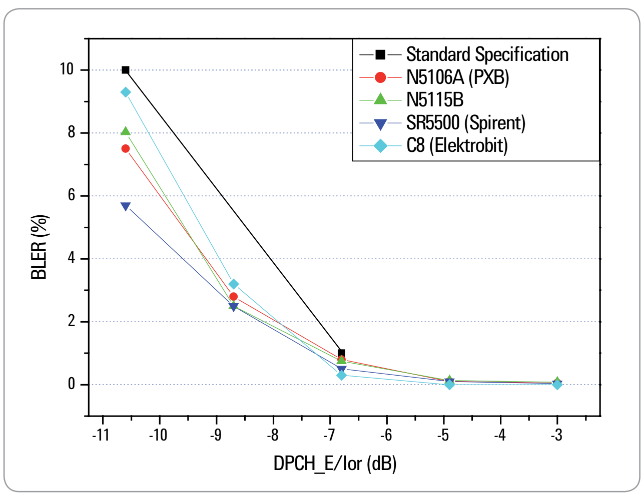

Figure 6-11. BLER versus DPCH_E/Ior curve of Test 3

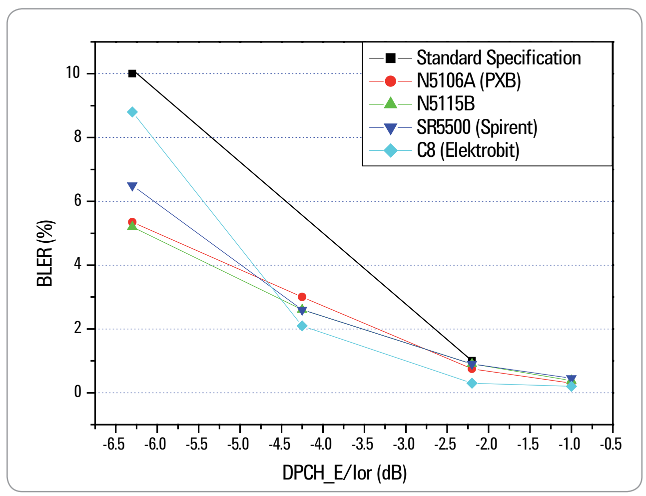

Figure 6-12. BLER versus DPCH_E/Ior curve of Test 4

The test results for the minimum requirements for Test 5-8, specified in Tables 7.3.1.3 and 7.3.1.4 in 3GPP TS 34.121-1 v8.6.0, are shown in Table 6-4.

Table 6-4. Test results for the minimum requirements, Test 5-8

Test number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
5	12.2	–9.7	1.80%	2.50%	3.70%	4.60%	–3	NA
		–8.7	0.90%	1.00%	1.30%	2.70%	–3	NA
		–7.7	0.40%	0.50%	0.60%	0.60%	–3	1%
		–5.7	0.12%	0.15%	0.25%	0.25%	–3	NA
6	64	–6.4	2.80%	4.40%	4.70%	4.80%	–3	10%
		–2.7	0.40%	0.50%	0.60%	0.60%	–3	1%
		–1.1	0.10%	0.05%	0.20%	0.10%	–3	NA
7	144	–8.1	2.65%	4.25%	4.50%	7.60%	3	10%
		–5.1	0.75%	0.45%	0.70%	0.45%	3	1%
		–2.1	0.10%	0.05%	0.10%	0.00%	3	NA
8	384	–5.5	1.92%	2.15%	2.10%	6.95%	6	10%
		–3.2	0.25%	0.35%	0.20%	0.40%	6	1%
		–2	0.10%	0.13%	0.10%	0.15%	6	NA

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-13, 6-14, 6-15 and 6-16, respectively.

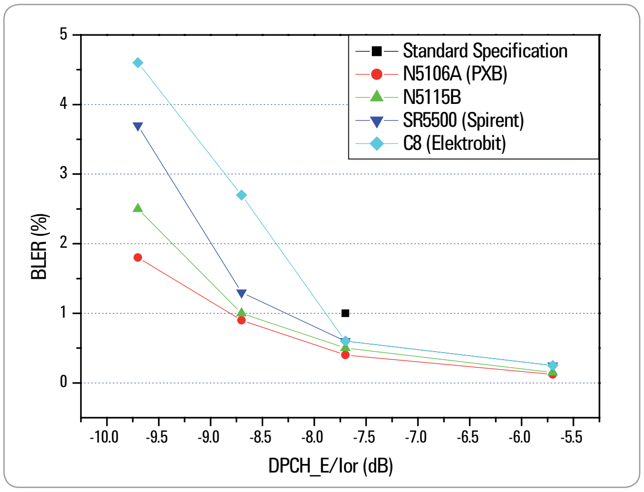

Figure 6-13. BLER versus DPCH_E/Ior curve of Test 5

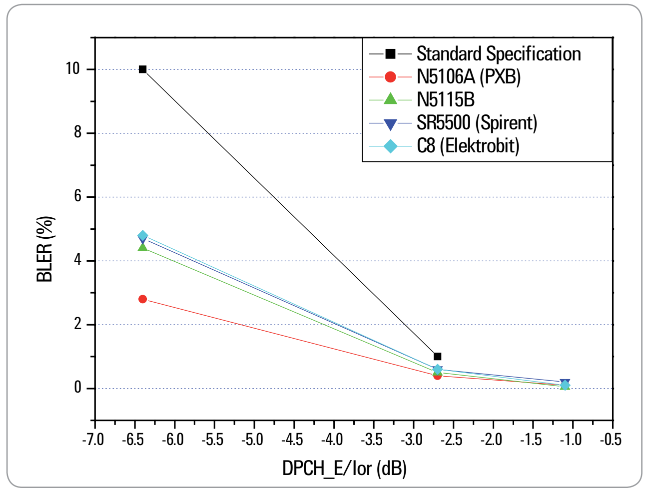

Figure 6-14. BLER versus DPCH_E/Ior curve of Test 6

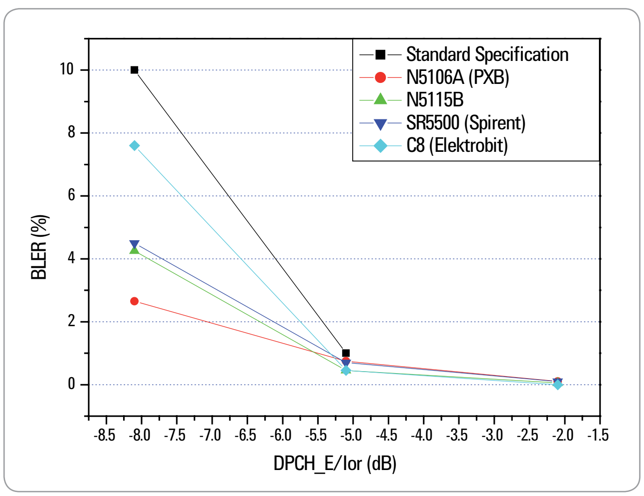

Figure 6-15. BLER versus DPCH_E/Ior curve of Test 7

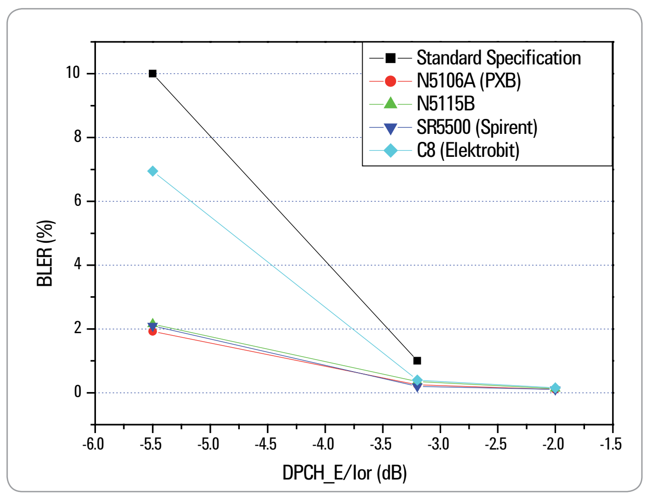

Figure 6-16. BLER versus DPCH_E/Ior curve of Test 8

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-17, 6-18, 6-19 and 6-20, respectively.

Table 6-5. Test results for the minimum requirements, Test 9-12

Test number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
9	12.2	–12.8	1.45%	2.00%	2.60%	4.60%	–3	NA
		–11.8	0.25%	0.50%	0.40%	0.40%	–3	1%
		–10.8	0.05%	0.05%	0.10%	0.03%	–3	NA
10	64	–8.1	1.25%	2.20%	1.60%	1.80%	–3	10%
		–7.4	0.40%	0.30%	0.60%	0.30%	–3	1%
		–6.8	0.10%	0.05%	0.15%	0.05%	–3	0.10%
11	144	–9	1.40%	2.60%	2.40%	2.40%	3	10%
		–8.5	0.40%	0.40%	0.70%	0.80%	3	1%
		–8	0.10%	0.10%	0.10%	0.05%	3	0.10%
12	384	–5.9	4.10%	3.50%	2.40%	3.80%	6	10%
		–5.1	0.60%	0.20%	0.20%	0.40%	6	1%
		–4.4	0.05%	0.10%	0.05%	0.05%	6	0.10%

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-17, 6-18, 6-19 and 6-20, respectively.

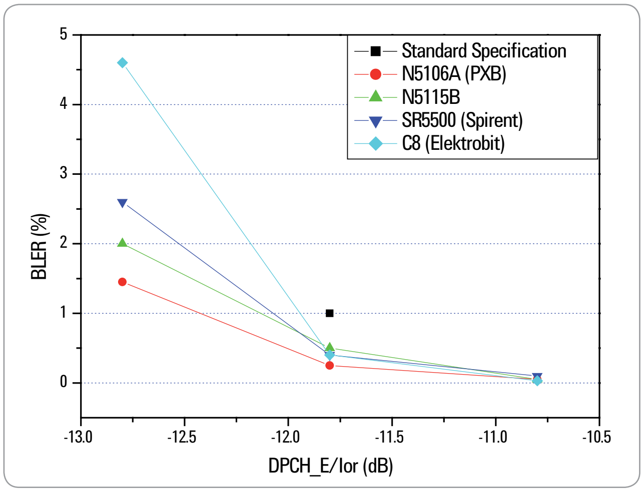

Figure 6-17. BLER versus DPCH_E/Ior curve of Test 9

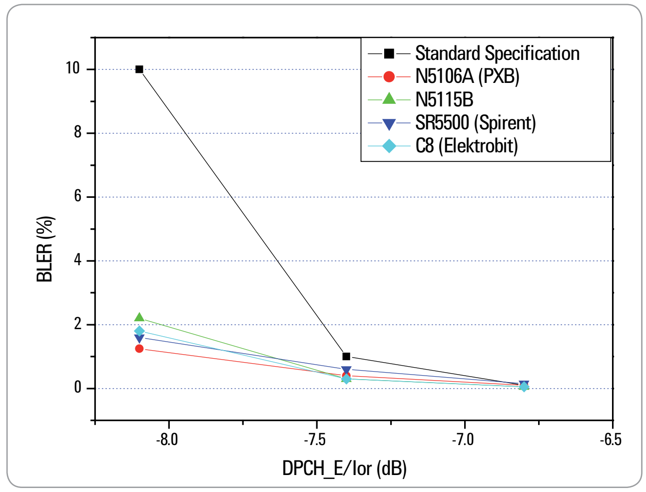

Figure 6-18. BLER versus DPCH_E/Ior curve of Test 10

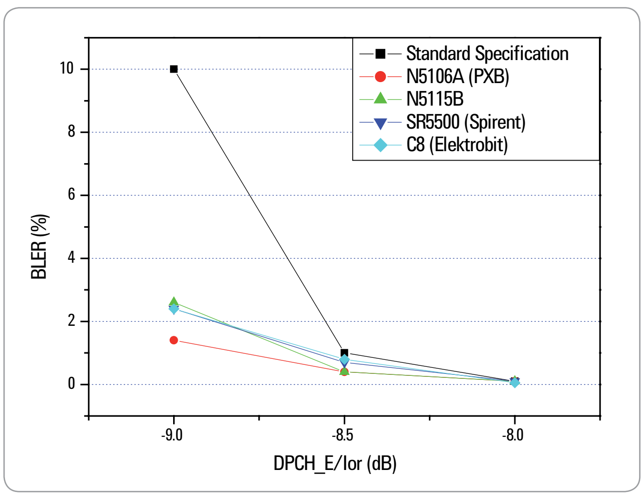

Figure 6-19. BLER versus DPCH_E/Ior curve of Test 11

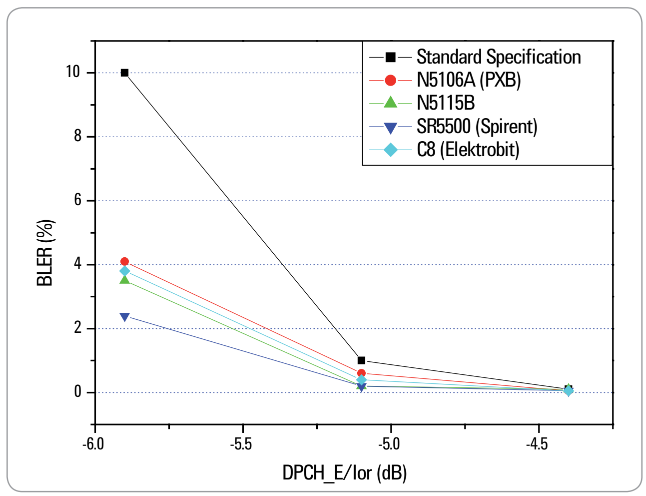

Figure 6-20. BLER versus DPCH_E/Ior curve of Test 12

The test results for the minimum requirements for Test 1-4 specified in Tables 7.3.1.11 and 7.3.1.12 in 3GPP TS 34.121-1 v8.6.0 are shown in Table 6-6.

Table 6-6. Test results for the minimum requirements, Test 1-4

Test Number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
1	12.2	–17.9	1.70%	2.10%	2.90%	5.90%	9.6	NA
		–14.9	0.30%	0.25%	0.40%	0.30%	9.6	1%
		–9.9	0.08%	0.03%	0.08%	0.00%	9.6	NA
2	64	–13.8	2.00%	3.60%	4.00%	8.20%	9.6	10%
		–9.9	0.13%	0.20%	0.70%	0.10%	9.6	1%
		–8	0.05%	0.05%	0.15%	0.00%	9.6	NA
3	144	–10.5	1.63%	3.30%	4.30%	8.30%	9.6	10%
		–6.7	0.30%	0.40%	0.70%	0.30%	9.6	1%
		–3	0.05%	0.08%	0.13%	0.00%	9.6	NA
4	384	–6.2	2.45%	3.70%	5.40%	6.30%	9.6	10%
		–2.1	0.43%	0.40%	0.55%	0.30%	9.6	1%
		–1	0.08%	0.20%	0.10%	0.00%	9.6	NA

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-21, 6-22, 6-23 and 6-24, respectively.

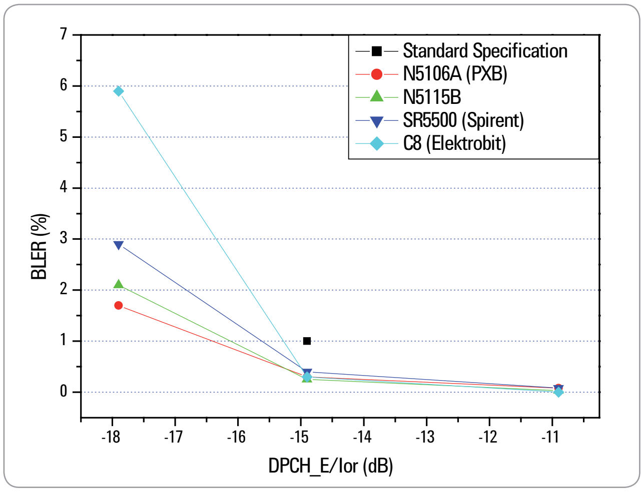

Figure 6-21. BLER versus DPCH_E/Ior curve of Test 1

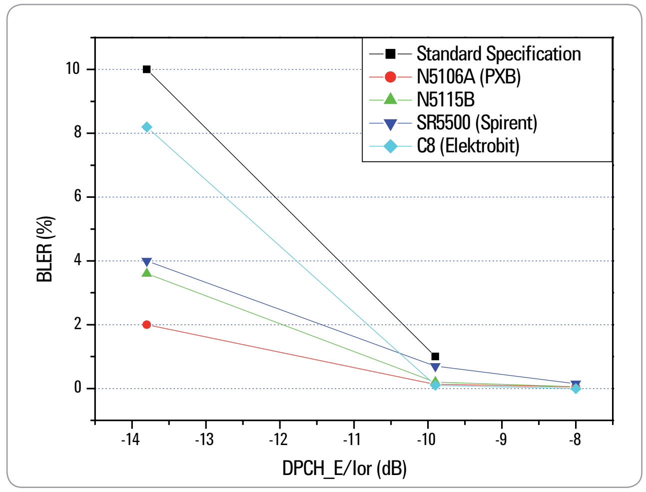

Figure 6-22. BLER versus DPCH_E/Ior curve of Test 2

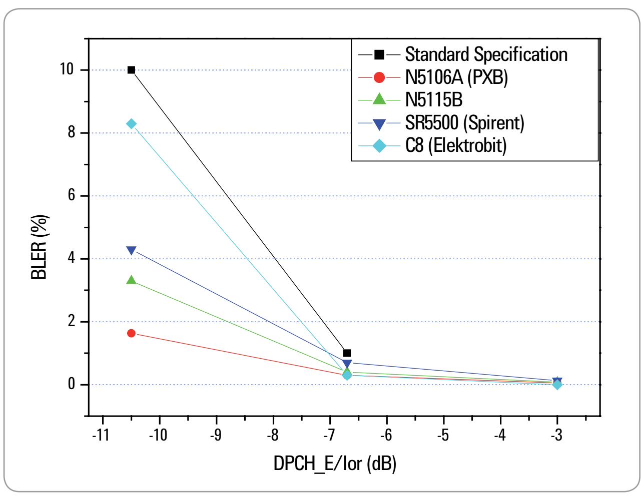

Figure 6-23. BLER versus DPCH_E/Ior curve of Test 3

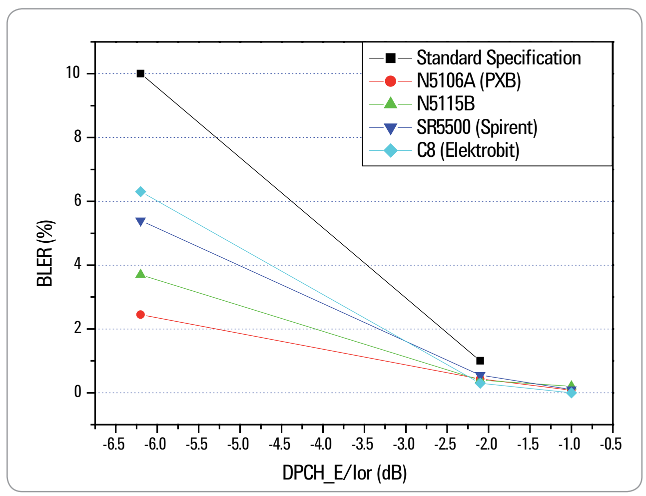

Figure 6-24. BLER versus DPCH_E/Ior curve of Test 4

The test results for the minimum requirements test 5-8 specified in Tables 7.3.1.13 and 7.3.1.14 in 3GPP TS 34.121-1 v8.6.0 are shown in Table 6-7.

Table 6-7. Test results for the minimum requirements, Test 5-8

Test Number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
5	12.2	–8.6	1.40%	1.35%	1.10%	2.40%	–2.4	NA
		–7.6	0.25%	0.40%	0.40%	0.40%	–2.4	1%
		–6.6	0.10%	0.10%	0.20%	0.05%	–2.4	NA
6	64	–6.3	1.17%	3.70%	3.40%	4.30%	–2.4	10%
		–2.6	0.40%	0.60%	0.45%	0.25%	–2.4	1%
		–1	0.05%	0.10%	0.20%	0.08%	–2.4	NA
7	144	–8	1.20%	2.70%	2.70%	6.90%	3.6	10%
		–5	0.16%	0.16%	0.25%	0.25%	3.6	1%
		–3	0.06%	0.10%	0.05%	0.00%	3.6	NA
8	384	–5.4	1.20%	1.70%	1.70%	5.60%	6.6	10%
		–3.1	0.24%	0.24%	0.35%	0.40%	6.6	1%
		–1	0.04%	0.05%	0.10%	0.00%	6.6	NA

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-25, 6-26, 6-27 and 6-28, respectively.

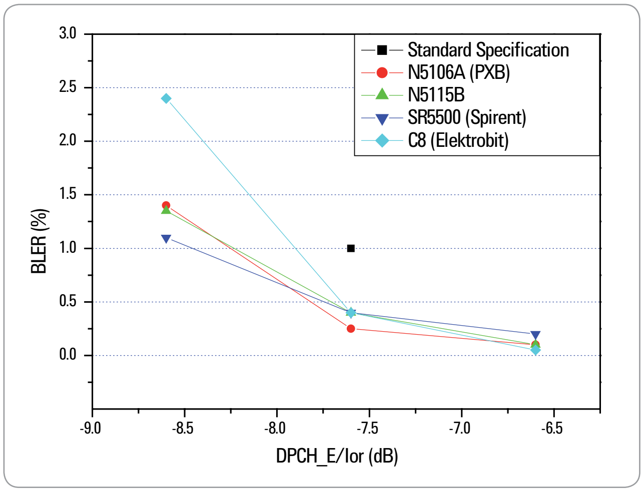

Figure 6-25. BLER versus DPCH_E/Ior curve of Test 5

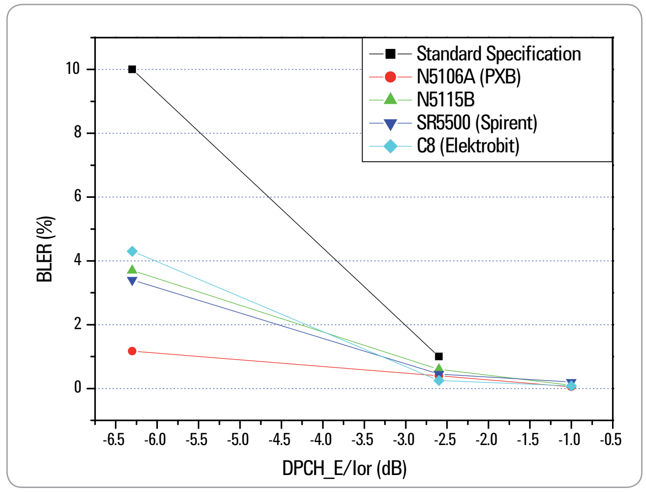

Figure 6-26. BLER versus DPCH_E/Ior curve of Test 6

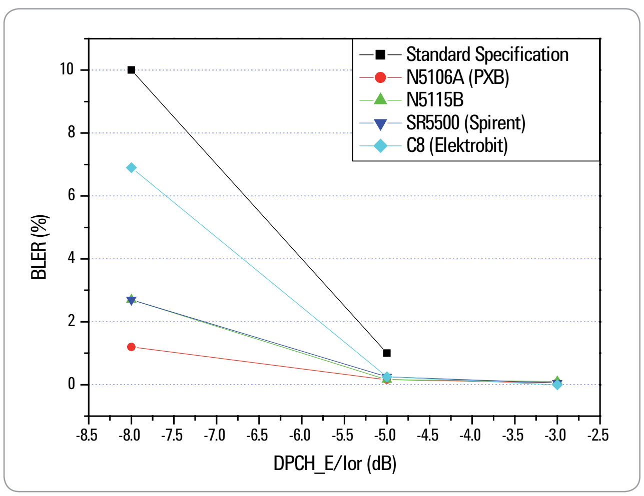

Figure 6-27. BLER versus DPCH_E/Ior curve of Test 7

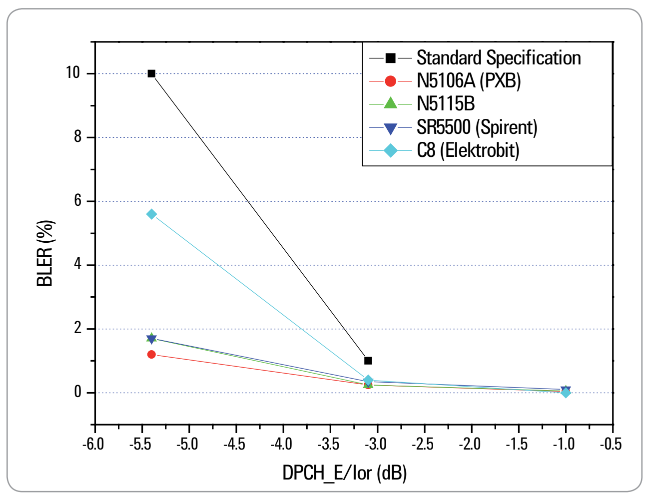

Figure 6-28. BLER versus DPCH_E/Ior curve of Test 8

The test results for the minimum requirements for Test 9-12 specified in Tables 7.3.1.15 and 7.3.1.16 in 3GPP TS 34.121-1 v8.6.0 are shown in Table 6-8.

Table 6-8. Test results for the minimum requirements, Test 9-12

Test Number	Data rate (kbps)	DPCH_E/ Ior (dB)	BLER (N5106A)	BLER (N5115B)	BLER (SR5500)	BLER (C8)	SNR (dB)	Ref BLER
9	12.2	–14.7	3.40%	3.00%	3.60%	5.40%	–2.4	NA
		–11.7	0.50%	0.20%	0.40%	0.40%	–2.4	1%
		–8.7	0.08%	0.10%	0.05%	0.00%	–2.4	NA
10	64	–8	2.50%	2.60%	2.10%	3.20%	–2.4	10%
		–7.3	0.40%	0.40%	0.30%	0.40%	–2.4	1%
		–6.7	0.09%	0.10%	0.10%	0.05%	–2.4	0.10%
11	144	–8.9	2.83%	3.40%	2.80%	3.60%	3.6	10%
		–8.4	0.33%	0.20%	0.30%	0.40%	3.6	1%
		–7.9	0.05%	0.10%	0.20%	0.05%	3.6	0.10%
12	384	–5.8	2.20%	2.50%	2.40%	2.20%	6.6	10%
		–5	0.13%	0.60%	0.50%	0.20%	6.6	1%
		–4.3	0.08%	0.03%	0.05%	0.00%	6.6	0.10%

The corresponding BLER versus DPCH_E/Ior curves are shown in Figures 6-29, 6-30, 6-31 and 6-32, respectively.

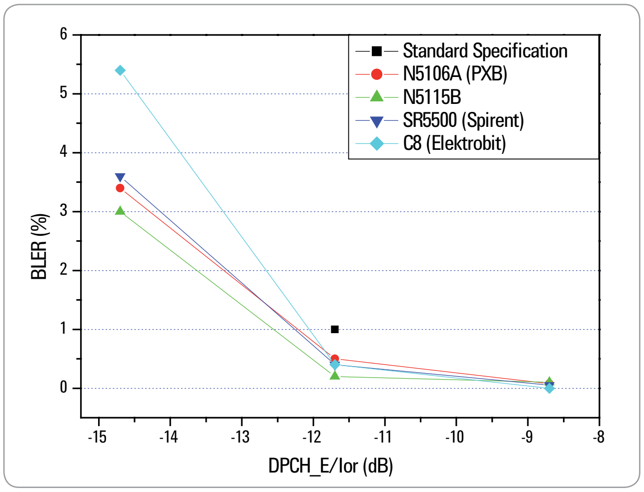

Figure 6-29. BLER versus DPCH_E/Ior curve of Test 9

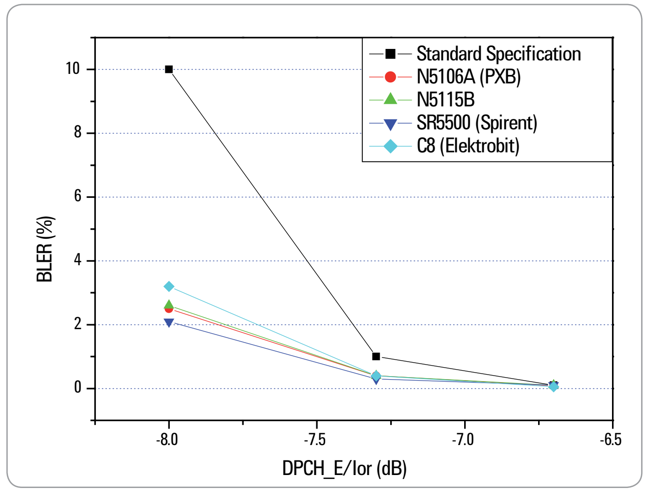

Figure 6-30. BLER versus DPCH_E/Ior curve of Test 10

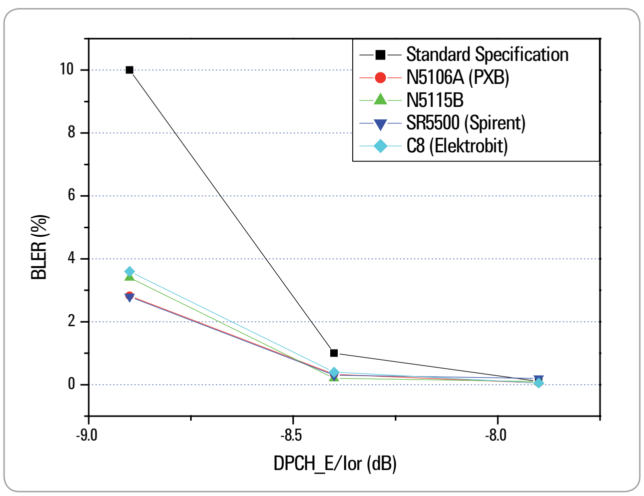

Figure 6-31. BLER versus DPCH_E/Ior curve of Test 11

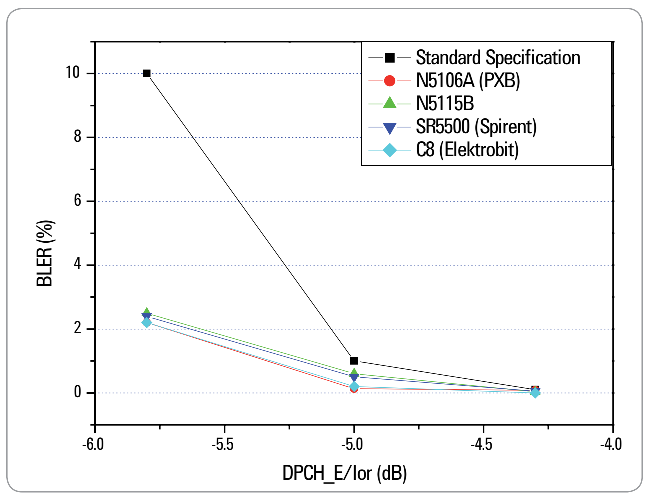

Figure 6-32. BLER versus DPCH_E/Ior curve of Test 12

7.0 Conclusion

RF fading is critical to generating proper signal impairments for wireless communication applications and ensuring user equipment robustness. The Agilent N5106A PXB baseband generator and channel emulator uniquely combines real-time fading with multichannel baseband generation and signal capture in a single, multipurpose instrument. In addition, it delivers fading performance that is comparable or better than other products dedicated solely to RF fading. When benchmarked using the BLER test, the PXB was shown to have similar fading performance to that of two commonly used channel emulators, the Spirent SR5500 and Elektrobit C8, and it fully satisfies the performance specification in 3GPP TS 34.121-1 v8.6.0. Most importantly, the PXB reduces the time, cost and complexity of system setup and calibration; and maximizes the user's investment through increased instrument utilization and easy upgrades.

8.0 References

[1] "3GPP TS 34.121-1 v8.6.0," pp 184-191 and 1132-1133.

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