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Mutual disturbance test method for evaluating performance degradation of converged terminal devices

Recommendation ITU-T K.94

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Mutual disturbance test method for evaluating performance degradation of converged terminal devices

Summary

With the rapid progress of the telecommunication terminal technology, more and more converged devices are appearing on the market. As the modules of the converged devices are so close together, if the printed circuit board (PCB) is not designed properly, without adequate earthing, shielding or filtering, an electromagnetic compatibility (EMC) disturbance can occur between the modules. Recommendation ITU-T K.94 analyses the EMC disturbance between different modules in converged terminal devices and defines a conducted test method. This mutual-disturbance test can be used as one of the immunity test items listed in Recommendation ITU-T K.34 and Recommendation ITU-T K.48 to determine the level of performance degradation.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T K.94	2012-05-29	5

FOREWORD

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Introduction

With the rapid progress of the telecommunication terminal technology, more and more converged devices are appearing on the market. Converged devices usually contain two or more modules which can transmit at the same time, for example: GSM/Wireless LAN dual mode terminal, WCDMA/Wireless LAN dual mode terminal, CDMA/Wireless LAN dual mode terminal, GSM/CDMA dual mode terminal. As the two modules are physically close to each other, if the PCB is not designed properly, without adequate earthing, shielding or filtering, an EMC disturbance could occur between the modules.

In order to limit the EMC disturbance between these modules, this Recommendation defines a test method that can be used as one of the EMC immunity test items on a converged device.

Recommendation ITU-T K.94

Mutual disturbance test method for evaluating performance degradation of converged terminal devices

1 Scope

This Recommendation analyses the electromagnetic compatibility (EMC) disturbance between different modules in converged terminal devices and defines a conducted test method. As more and more converged devices appear on the market, this Recommendation will help the industry to analyse and reduce such disturbance. Furthermore, this mutual-disturbance test can be used as one of the immunity test items listed in [ITU-T K.34] and [ITU-T K.48] to determine the level of performance degradation.

This Recommendation only covers the EMC mutual-disturbance between the different modules in converged devices. Examples of such devices include: GSM/Wireless LAN converged devices, WCDMA/Wireless LAN converged devices, CDMA/Wireless LAN converged devices and GSM/CDMA converged devices.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.34] Recommendation ITU-T K.34 (2003), *Classification of electromagnetic environmental conditions for telecommunication equipment – Basic EMC Recommendation*.

[ITU-T K.48] Recommendation ITU-T K.48 (2006), *EMC requirements for telecommunication equipment – Product family Recommendation.*

[ETSI TS 134 114] ETSI TS 134 114 (2008), *Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); User Equipment (UE)/Mobile Station (MS) Over The Air (OTA) antenna performance; Conformance testing (3GPP TS 34.114 version 7.0.0 Release 7).* <http://www.etsi.org/deliver/etsi_ts/134100_134199/134114/07.00.00_60/ts_134114v070000p.pdf>

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 converged device: A device containing two or more transmitters that can operate simultaneously. Examples of transmitter types are GSM, wireless LAN, WCDMA and CDMA.

3.2.2 minimum forward-link power: The minimum power of receiver BER (or FER) arriving to a certain level by the transmission of a base station.

3.2.3 standby mode: One mode of the converged device. In this mode, the module is registered to the network and can respond to a request from the network.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACK	Acknowledge
AP	Access Point
BER	Bit Error Ratio
CDMA	Code Division Multiple Access
EMC	Electromagnetic Compatibility
EUT	Equipment Under Test
FER	Frame Error Rate
FRR	Frame Reception Rate
GSM	Global System for Mobile communications
LAN	Local Area Network
NID	Network Identification
PC	Personal Computer
PCB	Printed Circuit Board
RBER	Residual Bit Error Ratio
RF	Radio Frequency
Rx	Receiver
SID	System Identification
UMTS	Universal Mobile Telecommunication System
WCDMA	Wideband Code Division Multiple Access

5 Basic test configuration

5.1 Test chamber

To avoid other disturbances, all the test cases should be performed in a shielded chamber as defined in clause 5.2.

5.2 Generic test set-up

An outline of the test set-up is shown in Figure 1. The converged device is put into a shielded chamber, while all the test equipment is outside of the chamber. To measure the conducted disturbance, the converged device modules should be modified to have a connection to a base station emulator via RF cables entering the shielded chamber. There will be two or more base station emulators depending on how many modules the converged device has.

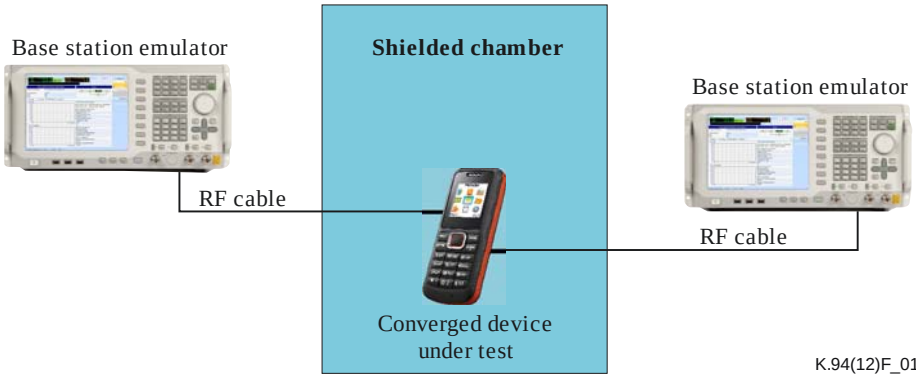

Figure 1 – Test set-up illustration of the converged devices

6 Generic test procedure

Assuming that the converged device has only two modules – module A and module B – the following procedures are used to determine the disturbance from module B to module A. The disturbance from module A to module B can be determined using the same procedure.

1) To perform this test, the converged device should be modified to include a test port connection for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module A with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module A according to the method of different product standards or Annex A of this Recommendation. During the test, module B should be set to the standby mode if module A has too many channels. It is acceptable if the separation between the two test channels is lower than 500 kHz.

5) Record the conducted sensitivity of each channel, as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module B with its network emulator at the lowest channel; the test settings should conform to the method of different product standards or Annex A of this Recommendation. During the following test, module B should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module A as specified in step 4) again. Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module A at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module B with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module B at the middle channel and high channel.

10) Record all the performance degradation results.

7 Test procedure for typical converged devices

Test procedures for some typical converged devices are given in this clause. For those converged devices not listed here, the generic method in clause 6 applies.

7.1 GSM/Wireless LAN converged device

7.1.1 General description

In this clause, the GSM module is module A and the wireless LAN module is module B.

7.1.2 GSM performance degradation test procedure

The following procedures are used to evaluate the GSM performance degradation in presence with the Wireless LAN module:

1) To perform this test, the GSM/wireless LAN converged device should be modified to include the test port connection for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module A with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module A according to [ETSI TS 134 114]. Measure the Class II residual BER (RBER) on module A. The number of frames observed shall be consistent with a 95% confidence level, but may be limited to 135 frames maximum. The measured RBER must not exceed 2.44% during the sensitivity search. During the test, module B should be set to the standby mode. If module A has too many channels, it is acceptable if the separation between the two test channels is lower than 500 kHz.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module B with its network emulator at the lowest channel; the test settings should conform to Annex A of this Recommendation. During the following test, module B should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module A as specified in step 4) again. Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module A at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module B with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module B at the middle channel and high channel.

10) Record all the performance degradation results.

7.1.3 Wireless LAN performance degradation test procedure

The following procedures are used to evaluate the wireless LAN performance degradation in presence with the GSM module:

1) To perform this test, the converged device should be modified to include the test port connection for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module B with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module B according to Annex A of this Recommendation. During the test, module A should be set to the standby mode.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module A with its network emulator at the lowest channel; the test settings should conform to [ETSI TS 134 114]. During the following test, module A should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module B as specified in step 4) again. Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module B at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module A with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module A at the middle channel and high channel.

10) Record all the performance degradation results.

7.2 UMTS/Wireless LAN converged device

7.2.1 General description

In this clause, the UMTS module is named as module A and the wireless LAN module is named as module B. For simplicity, only UMTS BAND I is used in this example.

7.2.2 UMTS performance degradation test procedure

The following procedures are used to evaluate the UMTS performance degradation in presence with the Wireless LAN module:

1) To perform this test, the UMTS/wireless LAN converged device should be modified to include the test port connection for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module A with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module A according to [ETSI TS 134 114]. Measure the BER on module A; the number of frames observed shall be consistent with a 95% confidence level. The measured BER must not exceed 1% during the sensitivity search. During the test, module B should be set to the standby mode.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module B with its network emulator at the lowest channel; the test settings should conform to Annex A of this Recommendation. During the following test, module B should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module A as specified in step 4) again. Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module A at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module B with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module B at the middle channel and high channel.

10) Record all the performance degradation results.

7.2.3 Wireless LAN performance degradation test procedure

The following procedures are used to evaluate the Wireless LAN performance degradation in presence with the UMTS module:

1) To perform this test, the wireless LAN/UMTS converged device should be modified to include the test port connection for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module B with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module B according to Annex A of this Recommendation. During the test, module A should be set to the standby mode.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module A with its network emulator at the lowest channel; the test settings should comply with [ETSI TS 134 114]. During the following test, module A should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module B as specified in step 4) again. Record the conducted sensitivity of each test channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module B at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module A with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module A at the middle channel and high channel.

10) Record all the performance degradation results.

7.3 CDMA/Wireless LAN converged device

7.3.1 General description

In this clause, the CDMA module is named as module A and the wireless LAN module is named as module B.

7.3.2 CDMA performance degradation test procedure

The following procedures are used to evaluate the CDMA performance degradation in presence with the wireless LAN module:

1) To perform this test, the CDMA/wireless LAN converged device should be modified to include the test port connection for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module A with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module A according to Annex B. Measure the FER on module A; the number of frames observed shall be consistent with a 95% confidence level. The measured FER must not exceed 1.2% during the sensitivity search. During the test, module B should be set to the standby mode.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module B with its network emulator at the lowest channel; the test settings should conform to Annex A of this Recommendation. During the following test, module B should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module A as specified in step 4) again. Record the conducted sensitivity of each test channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module A at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module B with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module B at the middle channel and high channel.

10) Record all the performance degradation results.

7.3.3 Wireless LAN performance degradation test procedure

The following procedures are used to evaluate the Wireless LAN performance degradation in presence with the CDMA module:

1) To perform this test, the Wireless LAN/CDMA converged device should be modified to include the conducted test port for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module B with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module B according to Annex A of this Recommendation. During the test, the module A should be set to the standby mode.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module A with its network emulator at the lowest channel; the test parameters should comply with Annex B. During the following test, the module A should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module B as specified in step 4) again. Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module B at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module A with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module A at the middle channel and high channel.

10) Record all the performance degradation results.

7.4 GSM/CDMA converged device

7.4.1 General

In this clause, the GSM module is named as module A and the CDMA module is named as module B.

7.4.2 GSM performance degradation test procedure

The following procedures are used to evaluate the GSM performance degradation in presence with the CDMA module:

1) To perform this test, the GSM/CDMA converged device should be modified to include the conducted test port for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module A with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all the channels of module A according to [ETSI TS 134 114]. Measure the Class II residual BER (RBER) on module A; the number of frames observed shall be consistent with a 95% confidence level, but may be limited to 135 frames maximum. The measured RBER must not exceed 2.44% during the sensitivity search. During the test, module B should be set to the standby mode. If module A has too many channels, it is acceptable if the separation between the two test channels is lower than 500 kHz.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module B with its network emulator at the lowest channel; the test settings should conform to Annex B of this Recommendation. During the following test, module B should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module A as specified in step 4) again, Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module A at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module B with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module B at the middle channel and high channel.

10) Record all the performance degradation results.

7.4.3 CDMA performance degradation test procedure

The following procedures are used to evaluate the CDMA performance degradation in presence with the GSM module:

1) To perform this test, the CDMA/GSM converged device should be modified to include the conducted test port for both module A and module B.

2) Put the converged device in the shielded chamber to minimize external disturbances. Only the converged device should be put in the shielded chamber; all the testing equipment should be put outside.

3) Connect module B with its network emulator using an RF cable. Before the test, the cable loss between the converged device and its network emulator should be measured and later used to compensate the test result.

4) Measure the conducted sensitivity of all channels of module B according to Annex B. Measure the FER on module B; the number of frames observed shall be consistent with a 95% confidence level. The measured FER must not exceed 1.2% during the sensitivity search. During the test, module A should be set to the standby mode.

5) Record the conducted sensitivity of each channel as $SEN_{ori\text{-}x}$, where x represents the channel number.

6) Connect module A with its network emulator at the lowest channel; the test settings should conform to [ETSI TS 134 114]. During the following test, module A should maintain the maximum power output condition.

7) Measure the conducted sensitivity of module B as specified in step 4) again. Record the conducted sensitivity of each channel as $SEN_{dis\text{-}x}$.

8) The performance degradation of module B at channel x can be expressed as $SEN_{deg\text{-}x} = SEN_{dis\text{-}x} - SEN_{ori\text{-}x}$.

9) Connect module A with its network emulator at the middle channel and high channel separately. Perform steps 6) to 8) again and determine the disturbance from module A at the middle channel and high channel.

10) Record all the performance degradation results.

Annex A

Wireless LAN receiver sensitivity test methodology

(This annex forms an integral part of this Recommendation.)

A.1 General description

The method used to determine the receiver sensitivity of Wireless LAN is based upon the Wireless LAN test set equipment, which will simulate the test AP. The test AP reports the number of ACK control frames per second being sent by the EUT in response to continuous unicast data packets being sent from it. The output transmitted power from the test AP needs to be calibrated before this test.

A.2 Unicast test packets

The unicast test data packets shall be 200 frame bytes at a rate of 50 frames a second, to approximate a voice data stream.

A.3 Frequency channels and data rates

On each frequency channel, receiver sensitivity shall be measured at the following data rate, which is the highest data rate it supports:

IEEE 802.11b: 11 Mbps

IEEE 802.11g: 54 Mbps

IEEE 802.11a: 54 Mbps

A.4 Test procedure

The test method to determine the receiver sensitivity conforms to the following procedure.

1) The AP attenuator in the Wireless LAN test set, which is the transmit attenuator, is set such that the signal received at the EUT is about 10 dB higher than the conducted sensitivity threshold.
2) The RX attenuator, in the Wireless LAN Test Set is set such that the received signal level from the EUT at the input of the Wireless LAN receiver is at least 10 dB higher than the conducted sensitivity of the Wireless LAN receiver.
3) The test AP is set up to transmit on the desired channel, modulation and data rate.
4) Connect the EUT with the AP.
5) The test AP is set to continuously transmit unicast data packets to the EUT.
6) The EUT responds to the received unicast data packets with an ACK control frame.
7) The Wireless LAN test set reports the reception of the ACK control frames to the control PC.
8) The control PC counts the number of data frames and the number of ACK control frames received over a time period needed to receive 1000 data frames and the corresponding ACKs. The FRR is computed as (# of ACKs received / # data frames transmitted).
9) Increase the AP attenuator, until the FRR reduces to the point where a 1 dB increase causes the FRR to be less than 90%.
10) Record the power at the EUT antenna port as the minimum forward-link power.
11) Repeat steps 1) to 10) for each required channel, modulation and data rate.

Annex B

CDMA receiver sensitivity test methodology

(This annex forms an integral part of this Recommendation.)

B.1 General description

Receiver sensitivity measurements shall be performed using the base station emulator to determine the EUT's receiver sensitivity by reporting the minimum forward-link power resulting in a frame error rate (FER) of 1.2% with 95% confidence.

B.2 Network parameters and test channels

- SID and NID are set according to the network parameters.
- Service option is set to 2 or 55.
- Forward-link power: as needed to maintain 0% FER.
- Power control: closed loop and always up.

B.3 Test procedure

The test method to determine the receiver sensitivity conforms to the following procedure.

1) Adjust the output power of the network emulator so that the signal received at the EUT is about 10 dB higher than the conducted sensitivity threshold.
2) The network emulator is set up to transmit on the desired channel and data rate.
3) The EUT connects with the network emulator by a cable.
4) The number of frames observed shall be consistent with a 95% confidence level but may be limited to 1000 frames maximum at 1.2% FER.
5) The forward-link power step size shall be no more than 0.5 dB when the RF power level is near the CDMA sensitivity level.
6) Record the power at the EUT antenna port as the minimum forward-link power.
7) Repeat steps 1) to 6) for each required channel.

Bibliography

[b-IEEE 802.11a] IEEE 802.11a-1999, *IEEE Standard for Telecommunications and Information Exchange Between Systems – LAN/MAN Specific Requirements – Part 11: Wireless Medium Access Control (MAC) and physical layer (PHY) specifications: High Speed Physical Layer in the 5 GHz band*.

[b-IEEE 802.11b] IEEE 802.11b-1999, *IEEE Standard for Information Technology – Telecommunications and information exchange between systems – Local and Metropolitan networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher Speed Physical Layer (PHY) Extension in the 2.4 GHz band*.

[b-IEEE 802.11g] IEEE 802.11g-2003, *IEEE Standard for Information technology – Local and metropolitan area networks – Specific requirements – Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Further Higher Data Rate Extension in the 2.4 GHz Band*.

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