IEEE P802.11
Wireless LANs

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| LB232 comment resolution for PHY-CCA—Part 1 |
| Date: 2018-05-30 (r0) |
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Abstract

Resolutions to LB232 comments on CCA and related topics (PHY-CCA comment group): 1194, 1468, 1470, 1471, 1472, 1478, 1479, 1480.

(The other comments in the PHY-CCA comment group are 1600, 1601, 1602. In addition, CID 1603 is currently assigned to “Submission required”, but it will probably be reassigned to the PHY-CCA comment group.)

Change history:

r0: Initial draft.

r1: Added 1480;

 Substantially redrafted background, discussion and proposed resolution for 1470 (cf. also 1471);

 Corrected typos in background for 1468.

r2: Substantially redrafted discussion and slightly redrafted proposed resolution for 1480.

r3 (November 14, 2018): Modified proposed resolutions to 1470, 1471 in accordance with suggestions by Youhan Kim.

## Comment 1194

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1194 | Guido Hiertz | 2624.00 | 15 | All PHYs (Clause 15 to 23) use various CCA schemes. Clause 15 mentions CCA Modes 1, 2, 3, and 6. Although CCA is common to the various PHYs, there is no single description. Instead, each PHY repeats text. Whereas the actual threshold levels may depend on a PHY's characteristics, there should be a common description of the various modes. | Prepend clauses 15 to 23 with a generic PHY clause that explains different CCA modes and lists aspects that are common to all PHYs. |

## Discussion for 1194

CCA is common to the various PHYs in the broad sense that they all have a CCA function. But they do not have the same CCA function, or even, in most cases, mostly the same CCA function. Comparing 15.4.6.5 (for DSSS PHY) to 23.3.17.5 (for S1G PHY), for example, the differences far outweigh the similarities. In particular, most text is not repeated in most CCA sections. It is not clear that there can be a useful common description of the various modes.

In any case, the proposed resolution does not provide one.

## Proposed resolution for 1194

REJECTED. The comment does not adequately justify the necessity or desirability of a change to the draft.

## Comment 1468

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1468 | Mark RISON |  | 19 | The HT rules for CCA as they pertain to non-HT transmissions are not clear. The issue is that if you don't know you're dealing with a non-HT transmission (which you don't know unless you successfully pick up the preamble) you don't know you have to apply the rules ("CCA sensitivity requirements for non-HT PPDUs") | Make it clear that the energy detect rules (not the CCA-ED rules, which are something different) from 18 and 19 apply even if you can't work out what type of PPDU/energy you're dealing with (these are "detect a medium busy condition within 4 us of any signal with a received energy that is 20 dB above the minimum modulation and coding rate sensitivity" for 2.4 GHz and -- hm, 19.4.6 has no energy detect requirement, that's in 19.3.4 ... but there's no just energy detect requirement there too. Does this mean HT has no just energy detect requirements (again, not talking of CCA-ED here) in the 5 GHz band? |

## Background for 1468

CCA requirements for HT STAs receiving non-HT PPDUs are described in 19.3.19.5.2 (CCA sensitivity for non-HT PPDUs): “CCA sensitivity requirements for non-HT PPDUs in the primary channel are described in 17.3.10.6 (CCA requirements) and 18.4.6 (CCA performance)” (2819.61).

Energy detect requirements for HT STAs are described in 19.3.19.5.3 (CCA sensitivity in 20 MHz): “The receiver shall indicate a channel busy condition for any signal 20 dB or more above the minimum modulation and coding rate sensitivity (-82 + 20 = -62 dBm) in the 20 MHz channel” (2820.6).

There is no clause 19.4.6, and 19.3.4 does not mention energy detect.

## Discussion for 1468

The comment is not clear. The CCA rules are stated as variations on the basic pattern “*if* a signal of this type is present, *then* declare channel busy, with at least some minimum probability”. See 17.3.6 “The start of a valid OFDM transmission … shall cause CS/CCA to detect a channel busy condition” (2715.38) and 18.4.6, “When the start of a valid ERP-OFDM signal or valid ERP-DSSS/CCK sync symbols … are present at the start of the PHY slot, the receiver’s CCA indicator shall report the channel busy …” (2732.30). An HT STA must always apply these CCA rules. If a non-HT PPDU is not present, the “if” part is not triggered.

The connection between the comment and the proposed change is also not clear: the comment deals with non-HT PPDUs, while the proposed change deals with pure energy detect.

In any case, the draft is already clear that pure energy detect is required for HT STAs, in both the 2.4 and 5 GHz bands: see 19.3.19.5.3.

## Proposed resolution for 1468

REJECTED. The draft already contains text matching the proposed change, in 19.3.19.5.3.

## Comment 1470

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1470 | Mark RISON |  | 16 | If aCCAtime needs to fit in slot time, does this mean it's necessary to detect a DSSS preamble within a slot time? This only allows about 8 bits of preamble, which seems insufficient. Even worse is "With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 us of the start of a MAC slot boundary, the PHY-CCA.indication(BUSY) primitive shall be generated before the end of the slot time.", which seems to require ability to detect a DSSS preamble within 4 us (9 us slots minus 5 us before the valid signal turns up after the start of the slot) for CCA modes 4 or 5, even if the rx-tx turnaround time is 0! | Clarify how aCCAtime works for HR/DSSS |

## Background for 1470

aCCATime for HR/DSSS devices is implementation dependent. See Table 16-4:

“aCCATime Implementation dependent: see 10.3.7 (DCF timing relations)” (2664.49).

The slot time for HR/DSSS devices is (at least) 20 s: see Table 16-4 (2664.42).

11g retained the 20 s (“long”) slot time and added an optional 9 s short slot time: see Table 18-5 (2736.42). ERP BSSs may operate with long slot time or short slot time, where short slot time can only be used where all associated STAs are ERP STAs that support short slot time (2737.30).

## Discussion for 1470

The proposed resolution asks for a clarification for how aCCATime works for HR/DSSS.

DSSS, HR/DSSS, ERP-DSSS, and ERP-CCK frames all share substantially the same preamble. A clarification for HR/DSSS will carry over to the other types. These will be referred to as “HR/DSSS (or variant) frames” in the following discussion.

Since aCCATime is implementation dependent and is subsumed into DCF timing relations, the comment appears to be asking for a clarification of how timing works in general within the CCA process, and, if the timing does not work for some cases, for changes to the draft to fix the problems.

There are several relevant factors:

1. Is the slot time in operation in the receiving STA’s BSS long or short?
2. Is the receiving STA NonERP or ERP / HT?
3. Is the incoming HR/DSSS (or variant) frame from the same BSS or from an OBSS?
4. Are the CCA rules at issue those from the HR/DSSS (or, equivalently, DSSS) clause or those from the ERP (or, equivalently, HT) clause?

This classification gives us up to 16 combinations to consider, but most of them can be dealt with quickly.

1. If the receiving STA’s BSS is operating with the long (20 s) slot time, there should be no problem. (Or, at least, the comment does not suggest there should be a problem.)
2. If the receiving STA is NonERP, its BSS must be operating with the long slot time, according to the rules listed above, and there should be no problem.
3. If the transmitting STA is NonERP and is in the same BSS, the receiving STA’s BSS must be operating with the long slot time, and there should be no problem.

Case 4―the receiving STA is ERP or HT, the receiving STA’s BSS is operating with short (9 s) slot time, and the CCA rules at issue are those from the ERP or HT clauses:

The ERP and HT CCA rules rules differ in one important way from the DSSS and HR/DSSS rules: for the former, the signal in question is assumed to be present at the start of the PHY slot (whatever that is: “MAC slot” appears in several other places, but this is the only place “PHY slot” is mentioned). See 18.4.6: “When the start of … valid ERP-DSSS/CCK sync symbols … are present at *the start of the PHY slot*, the receiver’s CCA indicator shall indicate channel busy …” (2732.30) (emphasis added). HT STAs also follow 18.4.6 (2819.60). So the delay of up to 5 s quoted by the comment does not apply to this case.

So for case 4 an ERP or HT device receives the start of an HR/DSSS frame, at the start of a PHY slot, while the (ERP / HT device’s) BSS is operating with short slot time. Assuming an Rx-Tx turnaround time of 5 s, this leaves 4 s for the receiver to make the detection decision. The comment says there are “only about 8 bits of preamble”, which “seems insufficient”.

The comment’s reference to the number of bits available for the decision is puzzling: receivers make detection decisions based on some combination of the correlation properties and the energy of the received signal. Cf. the start of OFDM preambles, which don’t contain “bits” at all. We assume that the signal is received over the air, but that there is no significant interference. The receiver has 4 s of received signal at a power level of at least -82 dBm. That is sufficient to achieve the required 90% probability of detection, with low probability of false detection, even ignoring all correlation properties of the signal. See for example “Energy Detection of Unknown Deterministic Signals”, H. Urkowitz, Proc. IEEE, vol. 55, no. 4, April 1967, pp. 523-531, especially Figure 9 (showing small loss compared to optimal detection of known signal).

Case 5―the receiving STA is ERP or HT, the receiving STA’s BSS is operating with short (9 s) slot time, the incoming HR/DSSS (or variant) frame is received with a delay of up to 5 s from the start of the slot, and the CCA rules at issue are those from the DSSS and HR/DSSS clauses:

The delay of up to 5 s from the start of the slot can happen if the frame originates from an OBSS. The question of whether the HR/DSSS (or equivalently DSSS) CCA rules apply to the receiving ERP or HT STA is (briefly) addressed below. If they do, then, as the comment correctly points out, the receiving STA could, in a worst case, start receiving the incoming frame starting nearly 5 s after the beginning of the slot, with a 5 s Rx-to-Tx turnaround time, leaving it with no time in which to make the detection decision. This is untenable: if the HR/DSSS CCA rules apply to ERP or HT STAs, the draft will need a change.

So after considering all the cases, there is a potential problem in just one of them, and even there only if the answer to the following question is “Yes”: Do the HR/DSSS (or equivalently DSSS) CCA rules apply to ERP or HT STAs?

There is some difference of opinion on this question. One view is that the CCA rules for each new PHY supersede those in older, constituent, PHYs. The other view is that an ERP PHY is itself a fully compliant HR/DSSS PHY with some extra functionality, so that the ERP device must satisfy the requirements of both the ERP and HR/DSSS clauses.

Rather than try to decide the issue definitively one way or the other, which might have unpredictable consequences, we can provide a narrow fix to the “case 5” problem above, by changing the HR/DSSS and DSSS CCA definitions.

## Proposed resolution for 1470

REVISED.

~~In 15.4.6.5 (2647.56) and 16.3.8.5 (2678.5), add the underlined text in item (b):~~

~~“With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 s of the start~~**~~, and present at the receiver antenna 9 s from the end,~~** ~~of a MAC slot boundary”.~~

In 15.4.6.5 (2647.56) and 16.3.8.5 (2678.5), add the underlined text in item (b):

“With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 s of the startof a MAC slot boundary, the PHY-CCA.indication(BUSY) primitive shall be generated before the end of the slot time **if aSlotTime is 20 s**”.

In 18.4.6 (2732.32), change “PHY slot” to “MAC slot”.

## Comment 1471

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1471 | Mark RISON |  | 15 | If aCCAtime needs to fit in slot time, does this mean it's necessary to detect a DSSS preamble within a slot time? This only allows about 8 bits of preamble, which seems insufficient. Even worse is "With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 us of the start of a MAC slot boundary, the PHY-CCA.indication(BUSY) primitive shall be generated before the end of the slot time.", which seems to require ability to detect a DSSS preamble within 4 us (9 us slots minus 5 us before the valid signal turns up after the start of the slot) for CCA modes 4 or 5, even if the rx-tx turnaround time is 0! | Clarify how aCCAtime works for DSSS |

## Background for 1471

CIDs 1470 and 1471 are very similar: 1470 concerns Clause 16 and HR/DSSS, while 1471 concerns Clause 15 and DSSS.

The portion of the beginning of any HR/DSSS frame that fits into any slot time is indistinguishable from a DSSS frame.

## Discussion for 1471

The background, discussion and proposed resolution of CID 1470 carry over.

## Proposed resolution for 1471

REVISED.

~~In 15.4.6.5 (2647.56) and 16.3.8.5 (2678.5), add the underlined text in item (b):~~

~~“With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 s of the start~~**~~, and present at the receiver antenna 9 s from the end,~~** ~~of a MAC slot boundary”.~~

In 15.4.6.5 (2647.56) and 16.3.8.5 (2678.5), add the underlined text in item (b):

“With a valid signal (according to the CCA mode of operation) present at the receiver antenna within 5 s of the startof a MAC slot boundary, the PHY-CCA.indication(BUSY) primitive shall be generated before the end of the slot time **if aSlotTime is 20 s**”.

In 18.4.6 (2732.32), change “PHY slot” to “MAC slot”.

## Comment 1472

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1472 | Mark RISON |  | 19.3.19.5 | "The thresholds in this subclause are compared with the signal level at each receiving antenna." -- why is this not stated for the HT PHY | At the start of 19.3.19.5 insert a subclause 19.3.19.5.1 GeneralThe thresholds in this subclause are compared with the signal level at each receiving antenna. |

## Discussion for 1472

The sentence cited in the comment is present in the CCA sections of Clauses 21-23. Other generalizations to multiple antenna systems would also be reasonable: for example, the thresholds could be compare to the average signal level across all receiving antennas. But the proposed change is reasonable and consistent with other clauses.

## Proposed resolution for 1472

ACCEPTED.

## Comment 1478

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1478 | Mark RISON |  | 16.3.6.8 | What does "The TX-to-RX turnaround time shall be measured at the air interface from the trailing edge of the last transmitted symbol to valid CCA detection of the incoming signal. The CCA should occur within 25 us (10 us for turnaround time plus 15 us for energy detect) or by the next slot boundary occurring after 25 us has elapsed (refer to 16.3.8.5 (CCA)). A receiver input signal 3 dB above the ED threshold described in 16.3.8.5 (CCA) shall be present at the receiver." mean? Does it mean that an 11b device can be "deaf" to CCA for 25 us after it has transmitted? | Reword to be clear that no, a device can't just skip CCA for 25 us |

## Background for 1478

SIFS is 10 s for DSSS and HR/DSSS PHYs (Table 15-5 (2639.29) and Table 16-4 (2664.47), respectively).

## Discussion for 1478

This section harks back to the oldest parts of the entire standard. Some of the issues involved may be obsolete at this point, and at the least several of them are mysterious. For example, what does the phrase “A receiver input signal 3 dB above the ED threshold described in 16.3.8.5 (CCA) shall be present at the receiver” mean?

Tx-Rx turnaround time is discussed in 11-93/147, “The importance of short Rx-Tx Turnaround time”, W. Diepstraten, September 1993 (which discusses Rx-Tx turnaround time also). Tx-Rx turnaround time was a factor in setting minimum interframe spacings.

Once the relevant other parameters are defined, there is no further need to specify the constituent parts. Nevertheless, it was common in the standard to spell out the constituent elements in explanation.

For later PHYs, Tx-Rx turnaround time is not mentioned at all, and Rx-Tx turnaround time is only mentioned to clarify that it is not defined (aRxTxTurnaround is “Implementation dependent, see 10.3.7 (DCF timing relations)”).

The SIFS for DSSS amd HR/DSSS is 10 s. A DSSS or HR/DSSS STA that finishes transmission must be able to receive an acknowledgment. The acknowledgment starts SIFS after the trailing symbol of the transmission. Thus, if we assume that the DSSS or HR/DSSS STA must be ready to start processing the acknowledgment by the time it starts, the Tx-Rx turnaround time must be at most 10 s. Then when processing the acknowledgment, the DSSS or HR/DSSS STA may take up to a further 15 s for energy detection, so that gives a total of 25 s up to the finish of CCA.

This seems to be what the quoted text is discussing. Admittedly the text is awkwardly phrased: the Tx-Rx turnaround time is measured from the trailing edge of the last transmitted signal to “valid CCA detection”, which is a strange way of referring to the start of the CCA process. But this seems the only reasonable interpretation.

The first two sentences describe the definition and requirement for Tx-Rx turnaround time. The third sentence (“The CCA should occur within 25 s …”) imposes no requirement and seems purely explanatory: it seems this can be deleted. The governing “shall” statements for CCA occur in 15.4.6.5 (CCA for DSSS STAs) and 16.3.8.5 (CCA for HR/DSSS STAs). The last sentence (“A receiver input signal 3 dB above the ED threshold described in 16.3.8.5 (CCA) shall be present at the receiver”) seems to be describing some sort of test and seems out of place. It too can be deleted.

The simplest and safest resolution is thus to retain the Tx-Rx turnaround time definition and requirement and to delete the rest, in both the DSSS and HR/DSSS clauses.

## Proposed resolution for 1478

REVISED. Delete the last two sentences of 15.4.4.7 (TX-to-RX turnaround time) and of 16.3.6.8 (TX-to-RX turnaround time) (from “The CCA should occur” to end of subclause in each case).

## Comment 1479

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1479 | Mark RISON |  | 15.4.4.7 | What does "The TX-to-RX turnaround time shall be measured at the air interface from the trailing edge of the last transmitted symbol to valid CCA detection of the incoming signal. The CCA should occur within 25 us (10 us for turnaround time plus 15 us for energy detect) or by the next slot boundary occurring after 25 us has elapsed (refer to 15.4.6.5 (CCA)). A receiver input signal 3 dB above the ED threshold described in 15.4.6.5 (CCA) shall be present at the receiver." mean? Does it mean that an 11-original device can be "deaf" to CCA for 25 us after it has transmitted? | Reword to be clear that no, a device can't just skip CCA for 25 us |

## Background for 1479

CIDs 1478 and 1479 are very similar: 1478 concerns Clause 16 and HR/DSSS, while 1479 concerns Clause 15 and DSSS.

The portion of the beginning of any HR/DSSS frame that fits into the first several slot times is indistinguishable from a DSSS frame.

## Discussion for 1479

The background, discussion and proposed resolution of CID 1478 carry over.

## Proposed resolution for 1479

REVISED. Delete the last two sentences of 15.4.4.7 (TX-to-RX turnaround time) and of 16.3.6.8 (TX-to-RX turnaround time) (from “The CCA should occur” to end of subclause in each case).

## Comment 1480

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| **CID** | **Commenter** | **Page** | **Clause** | **Comment** | **Proposed Change** |
| 1480 | Mark RISON | 3815.08 | C.3 | dot11EDThreshold is useless as it is undefined for PHYs other than DSSS and HR/DSSS | Delete dot11EDThreshold at the referenced location (lines 8-20) |

## Discussion for 1480

The comment asserts that dot11EDThreshold is useless because it is undefined for PHYs other than DSSS and HR/DSSS.

This is not quite accurate: the main problem is that dot11EDThreshold is not used for DSSS or HR/DSSS.

It seems that this threshold is intended to operate analogously to dot11OFDMEDThreshold, but for the single-tone modulations instead of for OFDM. dot11OFDMEDThreshold is used to define extra (more stringent than default IEEE) energy detect requirements that are imposed in certain regulatory domains, as described in Annex E.2 (cf. Annex D.2.5). Normative requirements involving dot11OFDMEDThreshold can be found at 2715.61 (for Clause 17), 2819.49 (for Clause 19), 2994.48 (for Clause 21), and 3069.46 (for Clause 22).

But there are no normative requirements for dot11EDThreshold. Annex E.2 does not list any additional energy detect requirements for the 2.4 GHz band, so at present there seems to be no need for dot11EDThreshold.

It still doesn’t (quite) follow that dot11EDThreshold is “useless”. If regulations in any domain concerning energy detect in the 2.4 GHz band change, then the threshold has some use (even if there is no normative requirement, and the regulatory information is not listed in Annex E.2). Admittedly, that’s a thin justification, but the text is there already and it doesn’t (quite) seem worth the trouble of removing it.

## Proposed resolution for 1480

REJECTED. dot11EDThreshold is not currently used, but it has a potential use.

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