**IEEE P802.15**

**Wireless Personal Area Networks**

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| Abstract | [Minutes of November 2017 Session]  |
| Purpose | [Description of what the author wants P802.15 to do with the information in the document.] |
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**Task group 802.15.13 met for 9 meetings during the November 2017 Plenary Session in Orlando, FL.**

**Meeting #1, Monday 06 November 2017, PM 1 (13:30 – 15:30)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Nikola Serafimovski (pureLiFi)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Ihtisham Khalid (Article 19)
* Xu Wang (VLNComm)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

Volker presented **doc. 15-17-0604r0**.

Patent slides are shown and the rules to attendance are explained. Chair discusses about the LOA issue and encourage the members to start early.

Chair introduced the modification to the July meeting minutes. The meeting minutes was updated and approved **doc. 15-17-0520r3** unanimously.

Chair introduced the agenda of the meeting with 8 dedicated slots and 1 joint slot to discuss the Vehicular Access Technology Interest Group (VAT IG) and the TG7m.

The agenda was discussed and agreed as **doc.** **15-17-0604r1**.

John presented **doc. 15-17-0582r0**. The key suggestion is to unify the writing style for the different PHY modes currently in the document.

The suggestion is to use a similar structure as 802.11ad, however, the specific style may need to be changed to reflect the best approach that might be more similar to 802.15.4.

There was a discussion if the Relaying elements of the current draft belong in the PHY section or somewhere in the MAC. This needs to be addressed by the original contributors of the text before it is retained in the next draft.

There was a discussion on where do each of the elements required to enable MIMO capabilities need to be located.

It was agreed that all of the PHY modes should have a similar writing style/structure. Each contributor should reformat the PHY contribution to follow the proposed outline in **doc. 15-17/0582r2**.

John discussed **doc. 15-17-0578r0**.

* There was a discussion on the removal of the Fast Link Recovery from the draft. The problem highlighted is that it might take a long time for the data rate on the link to recover the original data rates.
* John made the point that this is an implementation issue that can be addressed by carefully selecting the MCS levels.
* There was general agreement to keep the text in the document for now.
* The next point about the Optical Switch defined in Section 4 was discussed.

Meeting recessed until Tuesday, AM2.

**Meeting #2, Monday 06 November 2017, PM 2 (16:00 – 18:00)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Nikola Serafimovski (pureLiFi)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Yeong Ming Yang (Kookmin University)
* Xu Wang (VLNComm)

Joint meeting between 802.15.7m, 802.15.13 and the VAT IG.

The discussions is around the overlap between draft PAR and CSD published by VAT IG and the 802.15.13. The issue is that the current proposed PAR by the VAT IG, which the IG was not authorized to publish, has significant overlap with the work done in 802.15.13.

It was asked what is the difference between the VAT IG and how that is unique relative to the work in 802.15.13.

* Long range and high speed communications using OCC is the target of the VAT IG. The new target is data rates of over 10 Mbps and even achieving 100 Mbps at long distances
* It was asked for an explanation how these data rates can be achieved using camera communications. The VAT chair could not explain this point and would try to provide an explanation at a later time. A contribution should be ready for the March 2018 meeting.
* It was suggested to create an amendment to 802.15.7r1 to include these new capabilities.
* There should be a clear differentiation with respect to 802.15.7r1 and 802.15.13 as well as the new proposed system.
* 15.7r1 is mainly focused on OCC and 15.13 is mostly focused on a Photodiode and the new group would focus on high-speed OCC.
* IG VAT should provide more information on the technical and economic feasibility of the technology to continue the development on the work as well as to develop a new PAR/CSD draft.
* It was discussed again to delete the old PHY modes from the new revision of 802.15.7r1. But this is not intended by TG7m. It was noted that this will create coexistence issues between 802.15.7 and 802.15.13. TG7m has no plan to check for co-existence and even no time to check if all of the technologies included are working or not. Most are ok, but often there is no time to check if they work. There are currently no tests for PHY I – III. But there are videos showing OCC PHY modes from Intel, Panasonic and Kookmin University in operation. However, some OCC PHY modes have not been tested yet. TG13 members would prefer deleting PHY I-III from current 802.15.7m draft.
* The WG Chair mentioned that the technical feasibility is only asked after uniqueness and scope have been defined. This should be clearly defined in Jan 2018 together with the technical feasibility in March 2018. A presentation at the WNG meeting shall be given before asking for the formation of a Study Group. Need to have a clearly defined opportunity and gap in the market and a unique scope for the new VAT IG by end of Jan 2018 that is not clearly addressed by the two other light communications standards in 802.15. This is the basis for the scope along with the market opportunity and uniqueness.
* OCC VAT is looking only at uni-directional but bidirectional could also be considered.

The joint meeting was recessed.

**Meeting #3, Tuesday 07 November 2017, AM 2 (10:30 – 12:30)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Nikola Serafimovski (pureLiFi)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Xu Wang (VLNComm)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

The committee agreed that a full discussion was needed around the contentious elements from the various MAC and PHY proposals. The relevant text could then be generated after agreement on the exact structure and content.

John continued the presentation of **doc. 15-17/0578r0**.

The committee agreed with most of the provided suggestions in the document to remove the relevant text from the current draft wording. Specifically:

* The committee has agreed to accept:
	+ Proposal 2 – 6
* The committee has agreed to postpone the discussion on:
	+ Proposal 1

Sang-Kyu presented **doc. 15-17/0605r0**.

The discussion was around the removal of the various dimming functionality. The decision was made to remove the CVD frame from the MAC.

John presented **doc. 15-17/0579r0.**

The contribution tries to unify the different MAC frame types.

* Proposals 1, 2 were agreed
* Proposal 3 – to be discussed in a different context. Nikola will check the purpose of the Management Frame.
* Proposal 4, 5, 11, 12 – Nikola to provide more information on what they are used for.
* Proposal 6 – 10 were accepted

**Meeting #4, Wednesday 08 November 2017, AM 1 (08:00 – 10:00)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Xu Wang (VLNComm)
* Li Qiang-John (Huawei)
* Nikola Serafimovski (pureLiFi)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

Volker presented doc. **15-17-0598-00-0013**

Tables in slide 10 have been discussed. Volker: Connectivity matrix requires feedback. Use of “channel estimation” field in the frame as a means to estimate the connectivity. Proposed content is compared with G.hn and not 802.11 because it is very difficult to go through 3.000 pages of 802.11.

There has been another discussion about letter of assurance/patent policy. Is this required from anyone else since much content from G.hn is included in the proposed content. If we become aware of that, WG chair has to request a LoA from patent holder for G.hn. Can be discussed in joint meeting/conference call with G.hn group. LoA response is not guaranteed. Collaboration in a formal sense is desirable. If it is an essential material currently patented, the letter of assurance is required to have the content added to the standards. Since ITU-T is a closed club compared to IEEE, TG13 should initiate the conversation asap. TG13 needs an agreement with G.hn group that G.hn PHY can work with IEEE 802.15.13 MAC.

G. vlc is developed by chipset vendors in order to increase their market share, which in turn could affect their agreement with IEEE 802.15.13. Chip manufacture would like to include new media supported by their product. Discuss if this is “joint development” which was not considered in the PAR.

It was discussed if the multi-cell channel estimation frame is a MAC or PHY frame. Since each coordinator has its unique OWPAN ID therefore, it is its own beacon frame. The beacon frame transmitted from all coordinators should be a new frame which carries the ID of the master coordinator.

It was discussed if the concept could also be considered as distributed MIMO and all the MAC functions are shifted to the CO. One could consider MC as the coordinator. Only keep the PHY at the coordinators. I.e., it is a single coordinator with multiple antennas (LEDs/PDs).

Volker was asked to present the concept again in this way.

Meeting in recess until Wednesday, AM1.

**Meeting #5, Wednesday 08 November 2017, AM 1 (08:00 – 10:00)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Xu Wang (VLNComm)
* Li Qiang-John (Huawei)
* Nikola Serafimovski (pureLiFi)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

The meeting agenda was discussed again and agreed.

The possible liaison with the ITU-T in considerations of the G.vlc work is on-going. There is still development towards G.hn2 chipsets which will include G.vlc and therefore the G.hn is what we should be talking about in this group.

* Text was prepared in **doc. 15-17/0604r1** as the last slide.

Volker updated the group with some informal comments on D1 stemming from several AC group members about issues in the D1 text concerning security and wording on the upper layers. The 802.15 WG AC members advised that there is new text in the 802.15.4-2015 specification that provides an updated wording and new description of security that would be suitable for referencing. One should not include outdated text copied from outdated 802.15 standards into the new draft document. Considering these issues would certainly avoid a bunch of comments against the TG13 draft in the letter ballot process.

The discussion of **doc. 15-17/0598r0** was continued. The Master Coordinator should be outside the 802.15.13 scope. But upper layer functions of the MAC could be centralized. When this is considered as distributed MIMO, and LEDs/PDs are like antennas controlled by the same Coordinator. This would allow very fast coordination for resource allocation to the optical frontends.

Annother critical comment was that the coordinator mentioned in the proposed text has no handover which is inconsistent with the current draft. If there is a concept of Lower MAC (contention window, retransmission, etc.) and Upper MAC, this is not represented in the presented context. It is better to consider this as functions of the coordinator. As an example, sending the same beacon frame from all lights is then already included as it comes from one coordinator. The association would be inherently with the central unit and like in the Draft D1 this would be the coordinator.

Volker responded to be interested in the support of the distributed functionalities regardless if this is considered coordinator or master coordinator. It is essential to be able to handle a cluster of distributed lights as a in a coordinated manner with an open number of optical front-ends.

It was also discussed that interface between the optical frontend and the centralized part of the system should be left unspecified. It is also agreed that RF integration should be considered as well but not more like handover. There could be different ways to implement the current ideas where there is clustering and change of the clustering, but should be more based on the current specifications. Volker will provide an update document at the next meeting to reflect the new understanding of coordination as distributed multiuser MIMO.

The discussion on outstanding issues of the PHY was continued based on **doc. 15-17/0454r6**.

The main motivation of the Pulsed Modulation PHY is to have a simple system at hand that could even be implemented with ultra-low power and no DAC/ADC. However mobility still needs to be supported, already in a single link. There are two ways of achieving this:

* Keep the optical clock rate constant and vary modulation and coding scheme
* Vary the optical clock rate and keep the MCS constant

There has been a first discussion on these two options, tending more to keep the clock rates constant and doing the required link adaptation as part of the PHY/MAC design.

Then there was a discussion on defining the allowed optical clock rates. The current approach is 200 MHZ divided by a power of 2, which ends up with low frequencies where no oscillators exist. It was suggested initially to start with 320 MHz (which was seriously revised in the following session) because it would create more commonly found crystals on the market and reduce the implementation costs and energy consumption. 10 MHz clock optical clock may be good because this is the most common reference. This discussion has been postponed to the next session when more information on existing implementations is available.

There has been an initial discussion about the required code rates. The currently diverse numbers can be reduced and rather a common RS code with variable code-rate is introduced, which is implementable as long as the clock rate of the DSP is sufficient. The code rate can then be changed to provide an appropriate link adaptation.

Meeting is recessed until the Wednesday, PM 1 session.

**Meeting #6, Wednesday 08 November 2017, PM 1 (13:30 – 15:30)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Nikola Serafimovski (pureLiFi)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Bob Heile (WiSun)
* Xu Wang (VLNComm)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

The “reply letter to liaison statement from ITU-T G.vlc to 802.15” has been discussed with the WG Chair who needed some clarification first.

It was made clear that the whole PHY from G.hn shall be taken over and few modifications introduced that allow the desired mobility of the user among the optical frontends.  The reason for choosing G.hn is proven feasibility in combination with optical frontends and initial success on the market. Some technical support is needed from G.hn/G.vlc group to bring this forward. It was suggested to **use the G.hn content in the form of a reference, e.g., “We are going to use …” from ITU-T with following changes. If no language is copied, this needs no approval.**

IEEE can simply refer to the existing ITU-T specification and would add any necessary changes in its own documents. If the change needed is really big then it becomes not practical. If IEEE copies the content it will slow down the process. Just refer to the ITU-T document. That would be by far the easiest path. This avoids also any issues with patent or IPR. IEEE and ITU-T do have different policies. Best keep them separated. The WG chair wants to know if the change is going to be big.

Next topic is that it is difficult for several 802.15.13 members to attend ITU-T meetings because of membership issues. I would be easier if they could attend a joint meeting organized by IEEE where everyone can attend. This would be more easy if we provide a reply letter to ITU-T.

**The reply letter should mention that TG13 is developing a standard and want to exchange documents and share information.**TG Chair will send the letter draft to the WG chair after the meeting.

According to PAR, there is no intention for joint development. The WG chair clarified what a joint development is. If we are merging organizations it is a nightmare. They form a joint development committee. Both standards organizations appoint similar personnel to form a draft with equal membership. We all get comments. The joint committee needs to resolve the comments. Treaty organization or national bodies organization is usually very slow. And there is no reason for doing that. The WG chair was involved in an example is to have an IEC label on standards to be accepted globally. But it turned out one group wanted to own the copyright at the end. This should not be repeated.

Discussion on pulsed modulation PHY was then continued with doc. 0454/r5 and Table 106 in D1. One committee member wants to change this table, clock frequency should be multiple of 2 starting at 2 MHz up to 128 MHz for LB OFDM PHY. This was discussed controversially because it makes the discussion all over again. It was also suggested to change 10 MHz to 2.5. (regarding table 109 in D1). The discussion on clock rates is postponed to the next meeting.

Moreover, there was a technical question how to make different PHYs compatible. Several committee members are in favour of at getting the MAC super frame structures synchronized which would require PHYs to be synchronized as well. This needs consistent clocks. Implementation aspects have been discussed. For instance, if the basic clock of one PHY is 200 MHz, the divider 100 yields 2 MHz. If the other PHY has 10 MHz clock, as an example, it can the divider 5 also yields 2 MHz. At the 2 MHz clock frequency, there can be a PLL to synchronize one of the PHY clocks with respect to the other. Implementation of synchronous PHYs will be possible in this way. In principle, the common clock that is obtained by dividing the two clocks from each of the two PHYs can be used to synchronize both PHYs.Then different PHYs can be used even in the same MAC super frame if each PPDU can be decoded on its own. A a common super frame specification could then be used which can be decoded by each modem independent of the available PHYs.

**There should be at least one common clock in the set of clock rates defined for each PHY.**

**Clock rates will be put on the agenda again and discussed in January if more feedback from implementers is available.**

The discussion moved on to RS codes. There are two RS configurations for data and control message respectively. A dedicated MAC frame will be used to exchange the RS selection. Currently there are 4 bits to represent the RS. It was discussed what is the impact of a scalable code rate for link adaptation which was discussed previously.

MCS bits in D1 table 115 which is supported by original PHYs in the 802.15.7-2011, is considered obsolete. The current MCS is defined in table 116 (proposed by pureLiFi). Three bits are used there. Clock negotiation is done in a separate step in the new specification. Which makes three bits sufficient for LB PHY. Old and new specification use six bits for MCS and clock rate. Same field can be used with new definition of its content.The situation in HB OFDM PHY is different because adaptive bitloading is used. MCS specified in Table 121 can be changed on each subcarrier or for groups of subcarriers. It was noit clear if this selection can be done in the MAC layer. The adaptation is performed in the PHY, but the change made in the MAC. Change is made for a relative long time.

It was decided not to mix discussions of different PHYs and focus on pulsed modulation PHY.

Line coding was the next topic. 4B6B was used to mitigate flicker, 8B10B has higher rate compared 4B6B. For 4B6B the duration of consecutive 1s or 0s is shorter. For low data rates, this matters a lot for flicker mitigation. But at higher speed this is not important. The majority in the committee speaks in favour of 8B10B.

**The committee needs a short contribution for the impact of variable RS code rate on the performance to find reasonable step of the RS code rate. This is not available in the public literature.**

Basic work on PM PHY is almost done. The next step is to take the content and fit it into the skeleton. It is noted that still many things are missing, i.e.preamble, PPDU format, channel estimation etc.

The meeting is recessed.

**Meeting #6, Thursday 09 November 2017, AM 2 (10:30 – 12:30)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Xu Wang (VLNComm)
* Ann Krieger (US. Department of Defense)
* Joerg Robert (University Erlangen-Nuernberg)
* Ren Sakata (Toshiba Corp.)
* Soo-Young Chang (SYCA)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

The agenda was discussed again and agreed.

Plans for January 14-19 meeting were discussed and agreed. Document: **15-17-0604-02-0013.**

The comments submission against D1 was discussed. The procedure is to use the previous template, delete all comments, enter new comments and upload onto Mentor.

The overall schedule in **doc 0288-00-0013** is discussed, updated and agreed to **doc 0288-01-0013** for Nov. 17 to July 18. The update mainly includes postponing the tasks by one meeting to host at least two rounds of comments resolution. Start of the WG letter ballot is now scheduled for May 2018.

Xu Wang (VLNComm) is nominated by the chair as vice chair of 802.15.13 TG and approved with unanimous consent by the group in the meeting.

Discussion on the pulsed-modulation PHY was continued. The remaining work is definition of the preamble. The RS code rate of the header should be the lowest RS code rate used for data. Discussion is needed to figure out what should be the lowest RS code rate. It was also discussed if the same scrambler is used in all PHYs (within 802.15.13). LTE implements scrambler generator with infinite length, the data is truncated. Needs to check all PHYs whatr scrambling is used. The table of the polynomial table should be included in the specification, maybe in the Appendix.

The process of creating a shortened RS code word should be described. The text now reads:

Using the a RS(n,k) encoder, one can get a shortened RS(n-s, k-s) code as follows…

The detailed RS specification should not be discussed in the meeting, but through a proposal first. In 802.15.7, a convolutional encoder is used in conjunction with RS encoder. Moreover, the role of the interleaver has been discussed. It should be set as optional for now. Interleaver should be used by application basis. Forney provides an expedited way to construct interleavers.

The skeleton was for OFDM and has been modified to fit PM PHY. Line encoding is moved before PAM. Binary PPM (Manchester) is included for the purpose of dimming when resolved in time-domain. One PIB in MAC can be used to indicate 8B10B or binary PPM is used. When two line encoding methods are included, one should be mandatory, the other optional.

Meeting is in recess until Thursday PM1.

**Meeting #7, Thursday 09 November 2017, PM 1 (13:30 – 15:30)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Xu Wang (VLNComm)
* Nikola Serafimovski (pureLiFi)
* Ren Sakata (Toshiba Corp.)
* Soo-Young Chang (SYCA)
* Billy Verso (Decawave)
* Tim Harrington (Pro-ID consulting)
* Behcet Sarikaya (DenPelInformatique)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

The Pulsed modulation PHY is discussed **doc: 15-17-0454-07-0013**

It is discussed if dimming could be limited to amplitude. Manufacturers in Korea prefers time-domain dimming, i.e., binary PPM. Sang-Kyu needs to discuss this with the team members and provide a solution next time . The main question is how to select the line coding schemes.

The Technical editor asked for a reference for 8B10B to be included e.g. in the Technical Annex. Mohammad provides an 8B10B table available online <http://application-notes.digchip.com/056/56-39724.pdf>. The Technical Editor wants to include a detailed instruction on how 8B10B works.

Binary PPM is renamed Manchester in the specification. Again it was discussed that dimming feature should be left out of the text as implementation decision.

An indicator in the header tells the receiver the modulation, coding, line coding being used. The header should not be coded in certain line coding scheme, since it needs to inform the receiver what line coding (plus modulation etc.) is used in the data. The 2PAM and 4PAM are defined in one paragraph as PAM.

It was discussed again if and how to unify the preamble for all PHYs. Some committee members support to have the same preamble. This is however difficult for Pulsed Modulation as compared to OFDM PHY (constant vs. variable amplitude). LB OFDM preamble is defined in time domain, baut using 32 amplitude steps. HB PHY preamble should be defined in frequency domain. Committee members need to see the performance results of the suggested preamble to decide if agree with the unification or not.

Alternatively, a common PHY would be needed and implemented in the beacon frame to negotiate the supported PHY modes between 802.15.13 devices. 802.11 standards which claim backwards compatible do have a unified preamble.

The meeting recessed until Thursday PM2.

**Meeting #8, Thursday 09 November 2017, PM 2 (16:00 – 18:00)**

Attendees:

* Volker Jungnickel (Fraunhofer HHI)
* Mohammad Noshad (VLNComm)
* Li Qiang-John (Huawei)
* Sang-Kyu Lim (ETRI)
* Ryan Mennecke (John Hopkins University)
* Xu Wang (VLNComm)
* Nikola Serafimovski (pureLiFi)
* Joerg Robert (University Erlangen-Nuernberg)

The meeting was called to order by Volker Jungnickel (Fraunhofer HHI).

The committee discussed the preamble used in LB PHY where a that a time-domain sequence is used instead of OFDM and IFFT transformation method. It was again suggested that if preamble cannot be unified, we can use the common mode for the negotiating the PHYs.

It was discussed to arrange a phone call phone call dedicated to the preamble, channel estimation and header. It can be announced 10 days in advance over the WG email reflector. Material should be prepared and submitted to mentor at least two days before the phone call. The

time difference and acoustics often make phone calls impractical. Instead, call for proposals to be issued. Proposals shall be submitted one week before the next meeting (Jan, 8th).

It was discussed to have a call on the 9th so to have a clear view of the agenda from the beginning of the meeting. But discussions should happen only in the physical meeting. in person, in the January meeting. It was agreed to have no phone call before the January meeting.

A call of proposal is created for Pulsed Modulation PHY including PPDU, preamble, header, channel coding for header and data, scrambler, interleaver, etc.. The TG Chair is going to inform the working group at the closing plenary about this.

 “*TG13 requests full or partial proposals for Pulsed Modulation PHY, in particular*

*PPDU format, Preamble (Synchronization sequence, Channel estimation sequences), Header content, Header check sequence, Channel coding for the header, Channel coding for data with variable code rate, Scrambler, Interleaver*

*Proposals shall be submitted until January 7 and will be discussed at the Irvine meeting.* “

The high-bandwidth and low-bandwidth PHYs should also be put into the format of the proposed and agreed upon skeleton for the unified writing style. If additional content is necessary, content should be submitted as contribution.

It was agreed to postpone the resolution of the comments after the discussion of PHYs and focus on finalizing the Pulsed Modulation PHY in the meeting in January.

The meeting was adjourned until January in Irvine.