**IEEE P802.15.16t**

**Wireless Personal Area Networks**

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| Project | **IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)** |
| Title | **TG16t July 12, 13 and 14, 2022 Task Group Minutes** |
| Date Submitted | September 13, 2022 |
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| Re: |  |
| Abstract | IEEE 802.15 TG16t Meeting July 12, 13 and 14, 2022 Task Group Minutes. |
| Purpose | Report progress to WG |
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IEEE 802.15.16t July 12, 2022, TG16t Minutes

**July 12, 2022**

Tim Godfrey chaired and called the meeting to order at 1:33 PM EDT.

Attendance

* In person
	+ Tim Godfrey, EPRI, TG16t WG Chair.
	+ James Gilb, General Atomics Aeronautical Systems Inc. and University of San Diego
	+ Jörg Robert, TU Ilmenau and Fraunhofer IIS
* Remote
	+ Juha Juntunen, Meteorcomm
	+ Nathan Clanney, Siemens Mobility
	+ Menashe Shahar, Ondas Networks
	+ Vishal Kalkundrikar, Ondas Networks
	+ Daoud Serang, CML Microcircuits

Daoud volunteered to be meeting secretary.

Tim reviewed the agenda, in 802.15-22-0377r0, as well as IEEE meeting participation, policy and procedure requirements reviewed in detail during the July 11, 2022, 802.15 WG Opening Plenary meeting.

**June 15, 2022, TG16t Teleconference meeting minutes**

15-22-0324-00-016t-june-15-2022-tg16t-meeting-minutes.docx were reviewed. Daoud proposed changes reviewed via screen-sharing. Those changes were approved. He is to upload the resulting revised version, 15-22-0324r1, to Mentor.

**May 10 and 16, 2022, TG16t Teleconference meeting minutes**

The contents of 15-22-0263-00-016t-tg16t-may-05-2022-meeting-minutes and 15-22-0295-00-016t-tg16t-may-16-2022-meeting-minutes, for respective for the May 10th and 16th, 2022, TG16t meetings, were approved without revision.

**Contribution 15-22-0382-00-016t-tx-filtering-specs.docx**

Menashe gave the following review of points made and discussed in recent past TG16t meetings.

1. Document contributions describing the PHY did not specify or disclose Tx pulse shaping, i.e., filtering. It was suggested that such filtering is necessary to
	1. avoid phase discontinuities at adjacent m-PSK symbol boundaries otherwise those could make the Tx emission spectrum unable to comply with regulatory requirements (e.g., emission masks, ACPR limits etc.) applicable to the licensed channels that anticipated TG16t users report they will use,
	2. ensure that the 16t single subcarrier and multiple, adjacent subcarriers modulations can both practically comply with the same licensed channel narrowband regulatory emission requirements and
	3. ensure that when the described PHY employs multiple, adjacent, OFDM subcarriers, the required orthogonality of those subcarriers’ is not compromised by a Tx modulation filter applied to comply with emission regulations.
2. Ondas previously addressed point 1.a by noting that, without use of a Tx modulation filter, the described PHY’s use of a CP (cyclic prefix) and CS (cyclic suffix) on each OFDM subcarrier symbol precludes modulation phase discontinuities from occurring at adjacent symbol boundaries.
3. Prior Ondas contributions 15-22-0294-00-016t and 15-22-0293-00-016t addressed above points 1.b and 1.c by showing that (a) applying a combination of raised cosine windowing on the CP portion of each symbol and an In-Band Rejection (IBR) filter of unspecified response but of bandwidth spanning as many subchannels as are used, whether adjacent or not, and the resulting modulation can comply with licensed narrowband emission regulatory requirements and (b) so long as the IBR filter is implemented in a linear phase filter (e.g., FIR with symmetric coefficients) then subcarrier orthogonality will not be compromised or degraded by IBR filter response.
4. It was previously suggested that raised cosine windowing of each PHY symbol having CP and CS added would cause intersymbol interference (ISI) that unacceptably degrades link performance for QAM modulations of order higher than 4, e.g., 16-QAM and 64-QAM. Prior Ondas contribution 15-22-0322-00-016t addressed this point via simulation results showing that, for 256-QAM modulation, using 16-bit fixed point implementations of raised cosine windowing and an IBR filter yields adequately good SNR and EVM at the Rx detector, while also complying with FCC Part 90 mask D licensed narrowband emission requirements.
5. It was suggested that to support the 802.16t objective of enabling the development of interoperable 16t equipment across different manufacturers, the 16t amendment may need to fully specify modulation filter functions.

Menashe and Vishal presented contribution 15-22-0382-00-016t, *Windowing and Filtering Specifications for 802.16t Transmitter,* which considers a single subchannel (single OFDM subcarrier) modulation signal and describes the following sequence to develop it from a vector of over air symbols.

1. Insert Cyclic Prefix and Cyclic Suffix respectively before and after each symbol.
2. Apply raised cosine windowing across each resulting CP + symbol + CS combination.
3. In the time domain, “time pack” each resulting windowed, CP + symbol + CS combination more closely to the adjacent ones.
4. Filter the result with a parametrically defined (# of taps, passband and stopband frequencies, maximum passband ripple, and stopband attenuation) linear phase FIR designed using an exemplary digital filter design tool.

Menashe then reviewed 15-22-0382-00-016t simulation results showing, for 256-QAM, the processed Tx modulation’s spectrum vs. licensed narrowband FCC Part 90 mask D, and the resulting EVM, SNR and constellation diagram quality. He noted that Ondas deliberately decided to fully disclose both the precise windowing function and linear phase FIR filter design parameters in 15-22-0382-00-016t as one example that enables other manufacturers to implement the modulation without infringing any Ondas essential patent claims because Ondas has decided not to treat 15-22-0382-00-016t’s presented windowing and filter functions as proprietary to Ondas.

He and Vishal reported that other, undisclosed, windowing and or filter functions may suffice and that the specific windowing and filter functions might not need to be specified in the 16t amendment however Ondas would do so if that is needed.

Tim said that if the 16t amendment does not document the specific filter functions required to enable multi-manufacturer equipment interoperability then it would seem unlikely that the amendment would be approved.

James advised that if the 16t amendment includes such specific windowing or filter functions then the amendment must also consider how those functions’ implementations will be tested to verify compliance to the standard. He suggested specifying limits on EVM and ACLR or spectral mask, rather than specifying each of those functions in mathematical form. James also pointed out that if the pulse shaping filter is actually root raised cosine, not raised cosine, then the amendment would need to specify use of a root raised cosine filter in the receiver in both transmitter and receiver terminals. He also pointed out that an Rx equalizer could be used, if needed.

Daoud commented that 15-22-0382-00-016t *Figure 4 FIR filtered spectrum with FCC Mask-D* presents the modulation spectrum vs. the mask as having no margin, when some would be required, therefore, to comply with FCC Part 90 mask D, the modulation bandwidth would have to be reduced by reducing symbol rate and or changing the combination of windowing and pulse shaping filter functions. In response, Menashe said that the symbol rate could be reduced. Daoud noted that the resulting tradeoff is a proportional reduction in link throughput.

Vishal clarified that 15-22-0382-00-016t’s windowing filter response function is is raised cosine, not root raised cosine, whereas 15-22-0322-00-016t-filtering-considerations.pptx, reviewed in the last 16t meeting, employed an undisclosed, proprietary windowing function. He advised that the different windowing functions could potentially be used.

Jörg asked what length “transition area” the windowing function uses. Vishal responded that 16-24 samples of the 32 total CP samples are influenced by the windowing process and confirmed that the 15-22-0382-00-016t *Figure 4 FIR filtered spectrum with FCC Mask-D* spectrum is the result of both the raised cosine windowing and modulation pulse shaping filter, operating on a single subcarrier.

Jörg asked if the impact of applying windowing to the CP has been analyzed because such windowing distorts a portion of the CP and thereby reduce the ability to mitigate multipath. He explained that when receiving a multipath signal comprising mainly two paths, all samples of an unmodified (not windowed) CP are normally used to estimate then mitigate the multipath channel characteristic therefore, CP distortion by the described windowing may suggest link performance will degrade due to multipath. Vishal responded that if the windowing leaves a sufficiently large portion of CP undistorted then multipath channel effects can be mitigated.

Jörg summarized that the windowing function improves ACLR but reduces link multiple path tolerance.

James asked if a channel model has yet been selected against which to evaluate 16t air interfaces.

Menashe said that TG16t hasn’t yet selected channel models but Ondas’ simulations have used multiple channel models and he thinks that some are representative of typical 16t application scenarios. He added that Ondas will respond to the point about multipath tolerance but might not be able to during this week’s remaining TG16t meeting portions.

James shared his thought that a ground to air channel would present one of the more difficult channel responses and then asked how large a group delay spread had been considered. He added that use of high gain, directional antennas can reduce multipath degradation.

Menashe responded that users in the rail industry participate in TG16t and that rail industry user distances and relative speed needs are captured in 15-22-033-03-016t-802-16-system-requirements-document however a specific channel model has not been identified. He noted that the channel model originally used in past 802.16 development was for wider bandwidth channels than 16t will support therefore those past-used channel models may not be applicable. He suggested that channel models be proposed for 16t use.

Tim said that the subject of channel model should probably be revisited. It was agreed that channel model proposals should be sought.

As one idea, James said that perhaps16t could support changing CP length per deployment, making it short for channels that have a benign response but longer for channel responses that present more challenge.

Jörg asked if the target frequency band is ~400 MHz. Menashe responded that no single band is specified but that TG16t’s focus is on < 1 GHz, where multiple candidate bands have been identified and some are employed by users interested in the possibility of deploying 16t solutions.

Jörg asked what subcarrier spacing is planned. Menashe responded that 12.5 kHz is expected to be the most common one used because that is the common spectrum partitioning (channel spacing) used by, and available to, land mobile radio narrowband spectrum licensees interested in using 16t.

Jörg said he’ll identify the 3GPP channel model specification because he usually uses those. Menashe welcomed that information.

Menashe advised that Ondas will make some additional contributions this week, on PHY layer changes and preamble and ranging.

Tim asked if TG16t can start drafting 16t amendment content if TG16t agrees general principals on filtering and multipath. Menashe pointed out that it would be premature because MAC content hasn’t yet been addressed. Daoud said that before drafting amendment content, it would seem important to study proposed modulation filtering vs. emission regulations and the impact of channel characteristics, e.g., multipath, on link performance to confirm the technical viability and utility of technical proposals.

James reminded that the 16t amendment should not duplicate any pre-existing 802.16 specification content; it should instead include it by reference.

Jörg returned to the topic of whether to specify the Tx filter function in the 16t amendment and made the following points.

* If implementing a receiver, he would really want to use a priori knowledge of the Tx spectrum shape in combination with analysis of the Rx signal as the basis for estimating channel response then mitigating its multipath distortion.
* The existence of and specific response of the Tx raised cosine filter will significantly impact the accuracy of channel response estimation therefore the efficacy of channel distortion mitigation.
* Accordingly, to improve and benefit from that channel response estimating method, he highly recommends explicitly documenting the Tx filter specification in the 16t amendment.

Menashe that he understands Jörg’s comment and advised that his, Menashe’s, contributions on Tx filtering deliberately avoid specifying the Tx IBR filter response applied when multiple, not adjacent, subcarrier channels are used, because that Tx IBR filter response is Ondas intellectual property.

Jörg responded that if a Tx raised cosine filter is used then that filter and its alpha coefficient need to be specified to enable practical OFDM receiver implementation.

James noted that raised cosine and root raised cosine filter implementations must necessarily have finite response duration (be truncated), which is practical but not ideal, so the minimum time domain length implemented (amount of truncation) would need to be considered and might be an implementation choice.

The meeting recessed at 3:30 PM EDT.

**July 13, 2022**

Tim Godfrey chaired and called the recessed meeting back to order at 1:32 PM EDT.

Attendance

* In person
	+ Tim Godfrey, EPRI, TG16t WG Chair.
	+ James Gilb, General Atomics Aeronautical Systems Inc. and University of San Diego
	+ Jörg Robert, TU Ilmenau and Fraunhofer IIS
	+ Henk De Ruijter, Silicon Labs
* Remote
	+ Juha Juntunen, Meteorcomm
	+ Nathan Clanney, Siemens Mobility
	+ Menashe Shahar, Ondas Networks
	+ Vishal Kalkundrikar, Ondas Networks
	+ Daoud Serang, CML Microcircuits
	+ Sven Zeisberg, University of Applied Sciences Dresden
	+ Clark Palmer, Meteorcomm
	+ Dag T. Wisland, Novelda AS
	+ Kanke Wu, Qualcomm
	+ Jack Zou (affiliation not given)
	+ Pooria Pakrooh, Qualcomm
	+ Vamsi Amalladinne, Qualcomm

**Contribution 15-22-0397-00-016t-phy-layer-description**

Menashe contributed 15-22-0397-00-016t-phy-layer-description on July 12, 2022 and noted it is a new version of the Phy layer description previously submitted as DCN 15-22-210-00, on April 14, 2022. Relative changes were reviewed on screen and include:

* Section 3.7.1 Downlink data transmission, Figures 9 and 10 - Modified to add “RC Windowing on CP” and “Digital Filter” blocks.
* Section 3.7.1.1 Tx signal filtering – This section was inserted.
	+ Section 3.7.1.1.1 Raised Cosine Windowing - captures the RC windowing filter and CP addition and time packing content of 15-22-0382-00-016t.
	+ Section 3.7.1.1.2 Filtering – captures the single subcarrier filtering description of 15-22-0382-00-016t section 2.
* Section 3.7.2.1 Gold sequence - describes how to generate the Gold sequence and associated length options, based on configuration, which applies to the downlink (preamble).
* Section 3.7.3 Downlink FCH Transmission Figure 18 and Section 3.7.4 3.7.4 Downlink IOT-MAP Transmission Figure 19 - Modified to add “RC Windowing on CP” and “Digital Filter” blocks.
* Section 3.8.1. Uplink data transmission Figures 3-20 and 3-21- Modified to add “RC Windowing on CP” and “Digital Filter” blocks.
* Section 3.8.2 Ranging – Modified it back to using the Gold sequence, as defined for the preamble in section 3.7.2.1.

Tim raised the topic of how the content of contributions being discussed and other similar ones would eventually be captured as 16t amendment content. Noting that Harry Bims was expected to be the 16 amendment editor but isn’t attending this meeting, Menashe asked if Harry is still expected to be the editor. Tim that so far as he is aware, Harry continues to be the editor.

Menashe reminded that the prior day, TG16t agreed that more work needs to be done to consider the impact of multipath on link performance, given that some CP symbols are impacted by RC windowing.

**Contribution 15-22-0411-00-016t-ieee802-16t-preamble-and-ranging-sequences**

Vishal presented 15-22-0411-00-016t-ieee802-16t-preamble-and-ranging-sequences.docx, which analyzes autocorrelation and cross correlation of Zadoff-Chu (ZC) and Gold sequences across transmission delay and frequency mismatch/drift, noting that for no time or frequency error both ZC and Gold sequences yield the same autocorrelation performance.

Menashe noted that not all Gold sequences are good to use so those that are should be explicitly listed. Vishal agreed that could be done.

Tim asked if the Gold sequences are used only in the preamble. Vishal responded that the contribution’s analysis considers the sequences use in the preamble but the analysis is equally applicable to their use in ranging. Vishal noted 5 dB to 10 dB SNR is the range pertinent to the analysis.

A key point made is that for a single carrier system TOFF error (FOFF = ‑625Hz, Toff = 45), the ZC sequence timing was not accurate compared to what the Gold sequence achieves.

Jörg asked if the sequence was used on only a single subcarrier modulation. Menashe and Vishal confirmed that.

Jörg remarked that it was surprising that this was being used in the time domain, not as it is commonly used in the frequency domain as it is in LTE. Vishal and Menashe responded that the minimum bandwidth 16t channel contains a single subcarrier, for which case it is necessary to minimize single subcarrier PAPR. Jörg responded that a single subcarrier doesn’t exhibit high PAPR. Menashe responded that sometimes a Subchannel Group contains more than one subcarrier e.g. subchannels 3, 4, 5, and 6, in which case the sequence is transmitted only on one subchannel per subchannel group.

Tim asked for clarification of how many subcarriers can be in a subchannel.

Menashe responded.

There is always one subcarrier per subchannel. In prior meetings we discussed the ability, to minimize the number of subcarriers thus PAPR, the option to use multiple subchannel bandwidths e.g. a 12.5 kHz subchannel group and a 100 kHz subchannel group. If every subchannel is 12.5 kHz wide then those would respectively contain one and eight subcarriers. As a discussion topic, we also pointed out the possibility that a 100 kHz subchannel group could be single carrier however some analysis of that showed that its lack of orthogonality would interfere with subchannels containing one or more orthogonal subcarriers, and to avoid that interference would require what seem to be unacceptably large frequency guard bands of unused spectrum to separate the wider bandwidth single carrier subchannel from those containing mutually orthogonal subcarriers.

Jörg said that if OFDM subcarrier n = 128 then would an FFT over 128 be used. Menashe confirmed that. Given that, Jörg said he didn’t understand the prior point made about the need and way to achieve low PAPR for different subchannels. Menashe responded.

There are base stations and remotes. Each remote operates, at a given time, on one subchannel group. Low end remotes will especially operate on one subchannel and therefore have excellent PAPR. A base station can be more complex and use more power than a low end remote and thereby support multiple subchannels.

Jörg asked how the preamble would be used when there are multiple subchannel groups. Menashe responded.

Document 0397-00-016t describes self-sufficiency. See Figure 1. Think about a base station that supports all these subchannel groups whereas each remote operates on only one subchannel group e.g. a remote on subchannel 1 need not listen to or transmit on any other subchannel. For this reason, each subchannel group need only support one preamble.

Jörg said that transmitting the same preamble on coincident timing on multiple subchannels, e.g., Figure 1 Subchannel Group 1 (Subchannel 1) and Subchannel Group 2 (Subchannel 3) and Suchannel Group 3 (Subchannel 9), cannot be practically done because it would unacceptably increase PAPR at the base station transmitter, to the extent that link malfunction or transmitter damage can occur. Vishal responded that this high PAPR scenario could be avoided by using different preamble sequences for each subchannel group. Menashe added that perhaps the times at which same subchannel preambles are transmitted could be deliberately different, to avoid the high PAPR of coincidently timed, same preamble sequences.

Jörg advised that the high PAPR of this scenario often won’t appear in simulations so he cautioned that one should carefully consider the matter. Menashe reporting that the approach has been empirically operated, so it is not merely simulated or theoretical. Jörg added that a different standard committee encountered this same issue, which caused amplifier damage.

*Concerning synchronization…*

* Jörg: Concerning synchronization, normal OFDM uses the CP to remove the fractional frequency error so I’m surprised that you are using the preamble. If you don’t do that first then I’d use ZC, not Gold code, for the preamble. I’m not sure about phase jumps that occur in symbols if there is some frequency error.
* Vishal: We do timing sync via cross correlation.
* Jörg: So the preamble is modulated on one of the subcarriers. How do you do the correlation at the Rx side?
* Vishal: We slide in the time domain with single sample granularity and take the FFT and in the Freq domain we know the preamble code.
* Jörg: Then you lose performance.
* Vishal: We assume we aren’t synched. We extract the preamble sequences in the time domain.
* Jörg: So you’re doing a lot of FFTs for synchronization.
* Vishal: Yes.
* Jörg: But you still have frequency offset.
* Vishal: Yes, we correct that first.
* Jörg: That requires a lot of work, therefore more energy, than different approaches that I’d use. If terminals are battery-powered then that relative greater energy would reduce battery life.
* Tim: Will some 16t terminals be battery powered?
* Menashe: Remotes might be.
* Daoud: Some will but battery size may be greater than other apps would use.

Daoud asked Jörg if he could make a related contribution on this subject, because he (Daoud) could not possibly capture all the comments that Jörg made, which are helpful to crafting the 16t amendment. Jörg responded that at a future meeting he will make a submission that contains comments he would have otherwise made later in response to reviewing draft TG16t standard content.

James remarked.

The synch challenges and complexity apply to the remotes. Also, what if the synch sequence present in only one subchannel of a subchannel group happens to be in a fade? Another approach would be to include the preamble in every subchannel in a subchannel group and operate the receiver in a wide bandwidth mode to analyze and synchronize on all the group’s subchannels but after sync then demod only a single subchannel.

Tim asked if the preamble would always be assigned to the lowest numbered subchannel in a subchannel group or, alternatively, be dynamically assigned to different subchannels in a subchannel group. Menashe responded that it would always be assigned to the lowest numbered subchannel in a subchannel group. Tim said that the probability of a single subchannel being in a fade or subject to interference would have to be studied. Menashe and Vishal then said that, in principal, the preamble could be spread across all subchannels in a subchannel group.

Menashe added.

Taking a lesson from 802.16, we wanted to reduce PAPR, which is a huge problem, and reduce overhead, e.g., pilots that require distinct subcarriers unless you significantly increase the FFT. For that reason, we minimize the number of subcarriers per subchannel. In a prior meeting we considered the possibility of using more than one subchannel bandwidth so as to minimize the # of subcarriers therefore PAPR but we showed that the resulting lack of orthogonality between adjacent but different bandwidth subcarriers can require greater subcarrier separation than is desired.

Jörg said that if a channel’s response has short delay spread then it might work on a single channel however there will be a tradeoff in narrowband interference rejection.

Daoud noted that TIA TR-8 P25 considered various channel and interference models in detail because the licensed narrowband public safety solutions that P25 supports must perform adequately over a wide range of realistic channel models and interference conditions.

*Session ending technical comments…*

* Menashe: Yesterday we agreed that multipath effects need to be studied.
* Joerg: I submitted the 3gpp channel model.
* Menashe: Our priority is to focus on railroad apps.
* Jörg: So you mentioned that you don’t want to use pilots for channel estimation?
* Menashe: I said we don’t want distinct subcarriers to contain the pilot.
* Vishal: Some non-symbols will be pilots.
* Menashe: Not all scenarios are mobile, even in railroad apps.
* James: This is an interesting combination of single carrier with CP and OFDM.
* Juha: A link to TETRA spec models will be shared.
* Henk: The base station could have a higher performance PA and transmit a more traditional OFDM signal.
* Menashe: The base station communicates over some or all subchannel groups. It transmits the preamble on only one subchannel per subchannel group, the lowest numbered subchannel in each subchannel group.
* Henk: So data would be simultaneously transmitted on the other subchannels in a subchannel group?
* Menashe: Yes. The pilot would also be transmitted only on the lowest numbered subchannel in a subchannel group.
* Jörg: That won’t work because of the difference in frequency.
* Vishal: Pilots are transmitted in all subchannels of a subchannel group.
* Jörg: Ok, that would work.

*Administrative remarks…*

Tim reported that Clint distributed an IEEE 802 LMSC Leadership survey and asked that it please complete it by the end of today. He explained that the survey’s reason is that hybrid meetings are more costly to run than in-person only ones.

James announced that Paul Nikolich, current 802 Chair, won’t run for the Chair in 2014 so others may be interested in running. He added that Paul has been chair for twenty-one years and would welcome the participation of others, there also are a number of committee positions appointed by the chair that may be of interest and the published IEEE 802 LMSC Chair’s Guidelines describe the Chair role.

The meeting recessed at 3:30 PM EDT.

**July 14, 2022**

Tim Godfrey chaired and called the recessed meeting back to order at 1:30 PM EDT.

Attendance

* In person
	+ Tim Godfrey, EPRI, TG16t WG Chair.
	+ James Gilb, General Atomics Aeronautical Systems Inc. and University of San Diego
* Remote
	+ Juha Juntunen, Meteorcomm
	+ Menashe Shahar, Ondas Networks
	+ Vishal Kalkundrikar, Ondas Networks
	+ Daoud Serang, CML Microcircuits
	+ Nathan Clanney, Siemens Mobility

Menashe reported and reviewed the following.

* As expected, he and Vishal did not have enough time to consider and analyze multiple link performance and other technical work items raised earlier in the week.
* As background, to minimize PAPR, if we just combine subchannels then they need to be based on the minimum channel spacing granularity. Take for example the minimum of 12.5 kHz and have a subchannel group of 100 kHz bandwidth. In that case the 100 kHz subchannel group could contain four OFDM subchannels (adjacent OFDM subcarriers spaced by 12.5 kHz). By containing four subchannels, that 100 kHz subchannel group increases PAPR, which the 16t design is trying to avoid, especially for lower end remote terminals. This can motivate one to introduce a different, wider bandwidth subcarrier, say 25 kHz, that would enable the 100 kHz subchannel group to be occupied by only two 25 kHz subcarriers. The reduction in number of subcarriers (from 4 x 12.5 kHz to 2 x 25 kHz) will reduce PAPR. The tradeoff, as described two days ago, is that some of the allocated spectrum cannot be used for data transport because it instead must go unused to provide a frequency guard band.
* Vishal reviewed 15-22-0135-01-016t-phy-layer-design-considerations.pptx, which was originally discussed at the 2022 March meeting. A contribution showed that unless non-orthogonal subcarriers of different bandwidth are significantly separated in frequency they will cause mutual interference that degrades SNR by as much as 20-25 dB, which is significant.
* Spacing all subcarriers, across all subcarrier groups, on the same channel frequency separation grid, say 12.5 kHz, enables all subcarriers to be mutually orthogonal.

**Open 16t amendment development issues**

1. Multipath performance considering that the windowing filter “eats into” the CP.
2. How to resolve the PAPR of multiple preambles transmitted on each subchannel group. (Are the preambles simultaneously and
3. Identify which Gold sequences are good ones to use.
4. Add MAC layer content.
5. Review channel models.

**On whether future 802.15 meetings will be hybrid to support remote partipation**

When asked, Tim said that the next 802.15 session will be hybrid however they need future meetings to change to only in-person ones because the cost to support remote participants is too high.

Menashe responded that the cost to participate in person is high. Daoud also responded…

* The costs to fully participate, in financial and time terms, are significant, especially for the remote option that is the only practical option for many.
* His view is that such costs are a material obstacle to many, which is why they do not and won’t participate.

Tim clarified that his point was to say that a hybrid meeting carries an incremental cost over one that is in-person only.

**TG16t Timeline**

Tim displayed the timeline slide and said that TG16t isn’t likely to have a draft for review by the September 2022 data it indicates. That was agreed. James asked if it is time to start formally drafting the amendment, using portions of submitted contributions. Tim remarked that the contributions identified in 15-22-0377-03-016t-july-2022-plenary-meeting-presentation contain good content suitable to support starting to draft amendment 16t. Menashe and Daoud agreed.

The meeting adjourned at 2:28 PM EDT.