**April 14, 2022 802.16t Task Group Meeting Minutes**

# Attendees

Nathan Clanney – Siemens Mobility, Inc. (Secretary/note taker for this meeting)

Daoud Serang – CML Microcircuits

Guy Simpson – Ondas Networks

Menashe Shahar – Ondas Networks

Larry Foore – Cottron? (sorry, missed the spelling he provided)

Royce Connerley – Union Pacific Railroad

Tim Godfrey - EPRI

# Meeting Notes

Meeting started at 11:05AM PDT

Reviewed Agenda

* 3 submissions to review from Menashe

Reviewed IEEE Rules, Patent Policy, and Code of Conduct

Tim provided a status update for the working group

Overview of contributions

Review PowerPoint and air interface protocol contributions provided by Menashe on PHY Layer Design Considerations

* 15-22-0211-00-016t-phy-layer-design-considerations.pptx
* 15-22-0210-00-016t-air-interface-protocol-phy-layer-description.docx

Menashe went through each slide and described his perspective on each. Some discussion with participants.

Daoud discussed 15-22-0198-00-016t-ofdm-single-carrier-qpsk-papr.docx. He first reviewed the following points that Menashe made in his review of 15-22-0211-00-016t-phy-layer-design-considerations.pptx.

* Multicarrier OFDM provides benefit so long as the number of subcarriers is sufficient. Elevated PAPR (peak to average power ratio) is a direct tradeoff.
* For narrow bandwidth channels, say ones of 6.25 kHz or 12.5 kHz bandwidth, one can employ very few subcarriers. That diminishes OFDM’s benefits while not diminishing its elevated PAPR tradeoff.
* For that reason, it is worth considering single carrier modulation for narrower channels, even if a few OFDM subcarriers could be made to fit in the available, narrow bandwidth channel.

Daoud then explained his understanding of another OFDM tradeoff.

* CP-OFDM i.e. “regular OFDM using a cyclic prefix,” employs a rectangular pulse shape for each OFDM subcarrier. What that means is that each subcarrier’s modulation abruptly transitions from one QAM constellation point to the next per the symbol sequence (Tx data) that is modulating that subcarrier.
* Those abrupt subcarrier signal transitions make each subcarrier’s spectrum wider than what regulatory bodies normally allow in a 6.25/12.5/25 kHz licensed, narrowband RF channel. In other words, the subcarrier would emit unacceptably high power into adjacent channels (high ACLR – adjacent channel leakage ratio) licensed by other parties.
* CP-OFDM is normally used only in a wide bandwidth channel into which many subcarriers can fit however the subcarriers at the channel’s edge will still “leak” too much power outside of the channel. For that reason, typical CP-OFDM systems actually don’t even use the subcarriers located near the channel edge; they simply leave them turned off, which wastes that spectrum. This is often called the “guard band” of deliberately unused spectrum in an OFDM system. That amount of spectrum waste is tolerable when the channel bandwidth therefore number of utilized subcarriers is quite large. For example, if the channel bandwidth is 128 x a single subcarrier bandwidth then if the two subcarriers at each of lower and upper frequency edges are disabled to create a spectrum guard band, that represents only 4/128 = ~3% of spectrum waste. On the other hand, if the channel bandwidth is only one or two subcarriers wide e.g. 6.25 kHz or 12.5 kHz then none of those can be turned off to create a spectrum guard band.
* The types of modulations normally used in narrowband channels address this by deliberately avoiding abrupt transitions, or “jerking,” between successive QAM constellation points. This is achieved by applying a pulse shaping modulation filter and the raised cosine filter family is a very popular one that makes a narrowband modulation fit into one licensed, narrowband channel.
* Unfortunately, a raised cosine filter cannot be used with CP-OFDM. The reason is that CP-OFDM relies on a useful trait of the rectangular pulse shape employed by CP-OFDM.

Daoud noted that these are the reasons he previously asked what pulse shaping filter the TG16t OFDM modulation plans to use in licensed narrowband channels and how that will comply with applicable regulatory requirements.

Daoud also reviewed the following points covered at the March 2022 Plenary 16t meeting.

* It was reported that the 16t single subcarrier QPSK modulation is constant envelope and therefore has 0 dB PAPR.
* Daoud pointed out that only a select minority of QPSK modulations, e.g., shaped-offset QPSK, are constant envelope so he requested details on the proposed 16t subcarrier modulation’s pulse shaping function.

Covered Teleconference Planning

* May Wireless Interim requires registration

Meeting ended at 12:00PM PDT