802.15.4q PAR modification

Justification

- Current PAR is not aggressive enough
- Low power is important to 802.15.4, but we already have many low power PHYs
- If we are going to add a PHY to save power, it needs to be dramatically (10x) better
- Current PAR only specifies power, but not range, data rate and/or energy.

Energy considerations

- Bluetooth low energy (BLE) at 5 mW with 1 Mb/s is 5 nJ/bit
- -85 dBm sensitivity is normal for Bluetooth implementations
- With 100 kb/s, -95 dBm sensitivity is practical
- 0 dBm TX power, 0 dBi antenna gains, 95 dB link margin
- In the 2.4 GHz band, this corresponds to a range of 130 m with a path loss exponent of 2.5

Suggested numbers

- Peak TX and RX power of < 5 mW
- Data rate of 100 kb/s
- Range of 100 m
- Energy/bit < 5 nJ/bit

Suggested PAR change

- This amendment defines an ultra low power (ULP) physical layer operating in sub 1 GHz and 2.4 GHz license exempt bands supporting ~~typical~~ data rates ~~up~~ of ~~to~~ at ~~1~~ least ~~Mbps~~100 kbps at a range of typically 100 m. This amendment also defines the necessary MAC changes required for supporting the new ULP physical layer. The desired peak power consumption for the PHY should be typically less than ~~15~~5 mW and the energy per bit transmitted should be less than 5 nJ.

Entry for 8.2

- For a PAR modification, 8.2 needs to contain the reason for the change with the line numbers:
- 5.2b Discussion in the working group revealed that the scope did not sufficiently constrain the problem, for example, by specifying the desired range. In addition, The current state of the art in low power radios is lower than 15 mW. Battery life depends on the energy per bit which was not specified in the previous PAR.

Motion

- Request that the PAR and CSD contained in documents 15-14-581-00 and 15-14-387-06, respectively, be approved by the 802.15 WG and that the 802 EC be requested to forward the revised PAR to NesCom. The 802.15 working group chair and technical editor are authorized to make additional modifications to the PAR and 5C as needed to reflect EC discussion at its closing meeting.
- Moved: Gilb, Second:
- Y/N/A

Power amplifier

- For high TX power applications, the PA may be a significant contribution to the power
- Complex modulations can require operation at inefficient power levels
- Methods:
  - Select modulation that can operate at Psat, e.g., FSK or BPSK (QPSK sometimes)
  - Use ASK and turn off the PA
    - Need to worry about “splatter”

Baseband

- The digital baseband complexity adds to power usage
- This tends to hit the receiver more than the transmitter, but that is more important than transmitter power for ULP devices
- Methods
  - Don't use FEC, it doesn't help in interference environments (i.e., real environments)
  - Use a simple coding (e.g., FSK and ASK) in which the bits can be applied directly to the analog portions of the radio.

So, what is a ULP radio?

- ASK, 2 level, Manchester encoding, 1% frequency accuracy for RF and symbol rate.
  - Can turn PA and LO on and off
  - No synthesizer required
  - Timing recovery is easy
  - Direct modulation possible

Another ULP

- 2-FSK
  - Allow frequency drift so synthesizer can be turned off before transmission
  - Easy Direct modulation allowed because loop is turned off
  - TX chain is VCO and PA only
  - 8b/10 coding for timing recovery

What not to do

- Combine frequency and ASK
  - Current TASK has none of the advantages of either BPSK/FSK and ASK
  - LO must stay locked because phase coherency is required
  - Only PA can be turned off, but for a ULP device, the PA is a small portion of the power.
- Use complex coding methods
  - Burns power on TX and complicates the receiver
  - Doesn't help performance because we are not SNR limited by interference limited
  - Even in SNR limited environments, the gain only happens at the far edge of coverage, close in, there is no advatage

What do we do?

- Vote no on the letter ballot and submit comments
  - Change the PHY to a real ULP solution
  - Use two-level coding, not ternary
  - No FEC, it wastes power and provides no advantage in an interference environment.
  - Relax frequency and timing requirements
  - Use a well known, simple encoding (Manchester or 8b/10b) for timing recovery