PHILIPS BOSCH NXP

Slot scheduling proposal

Slot scheduling to agree Communication and FOD during slots

Proposal to

General Wireless Power Specification

2019-09-09

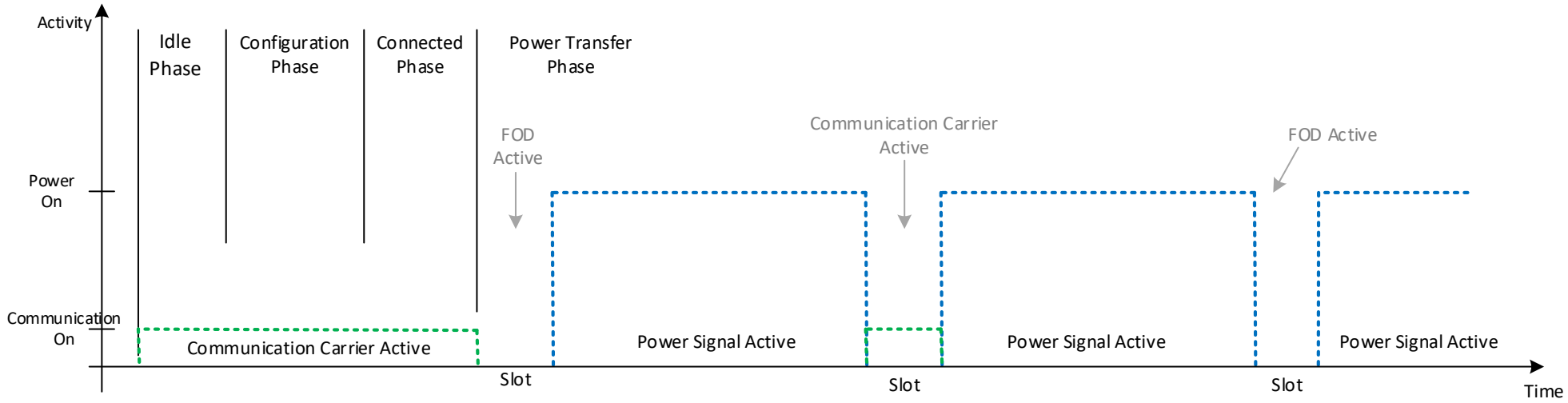
Outlook

- Open point in specification – slot scheduling
- Slot scheduling proposal
- Conclusions

General Wireless Power Specification

Recap on slotted communication and FOD principle:

- Figure 6, section 2.5 defines the phases of the power transfer protocol



Slots during Power transfer

- PRx requirement
  - PRx as master of the charging application requires communication during slots to control the charging process and to exchange information
  - **Communication must occur on a regular basis during slots**

- PTx requirement
  - PTx is responsible for system safety. Thus must ensure that FOs are reliably detected within a short period of time.
  - **FOD must occur on a regular basis during slots**

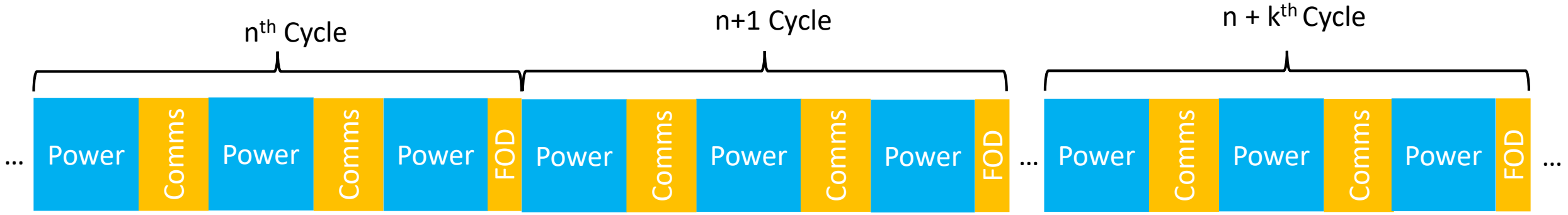
PTx and PRx requirements above may get in conflict if not defined in the standard!

Slot scheduling proposal

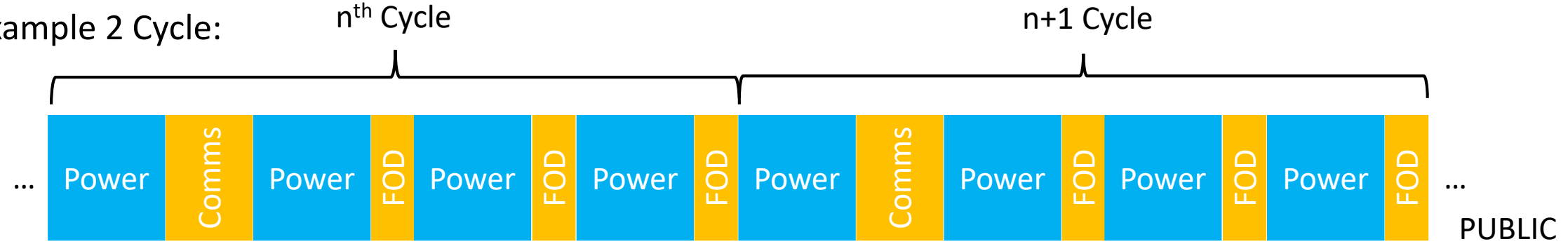
- Shall be defined in “General Wireless Power Specification”
  - Thus must be flexible enough to be applied for all targeted applications, i.e., cordless kitchen and medium power battery.
- In general two options for solution
  - Perform FOD ad hoc in a slot → results in a none predictable situation and hard to control in a standard
  - Predefined and agreed arrangement → clean and efficient way; easy to define and easy to test
- Goal: Define a mechanism how to agree in which slot communication and in which slot FOD is performed!

Slot scheduling proposal - Basics

- Define the smallest unit consisting of at least two power periods (T_{power}), one communication and one FOD slot
  - This smallest unit is called: Cycle
- A cycle is repeated over and over again until charging is terminated
- Example 1 Cycle:

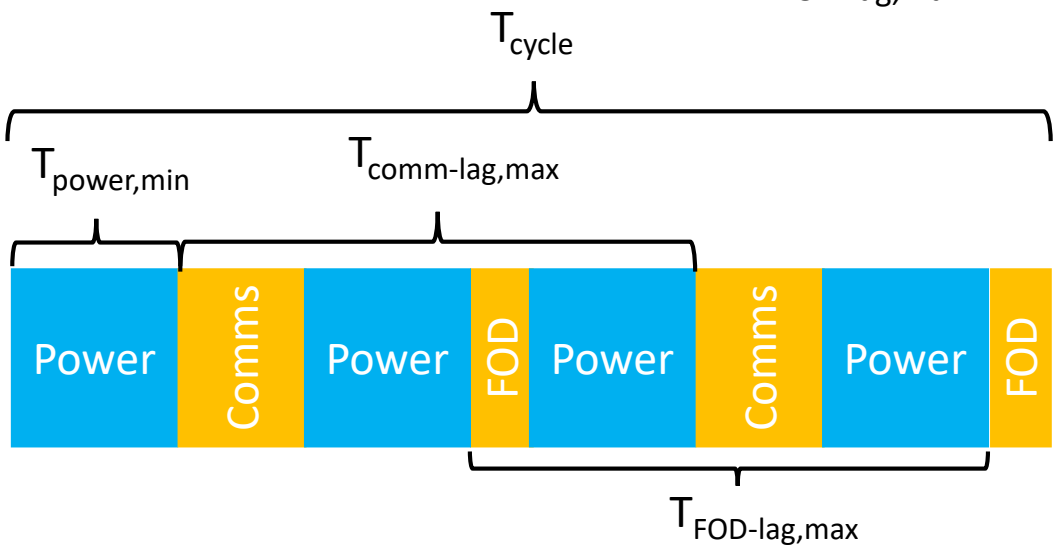


- Example 2 Cycle:



Parameter Definition

- PRx defined:
  - Minimum time duration of the power signal ($T_{power,min}$)
    - Ensure operation of PRx, and guarantees min efficiency
    - For cordless kitchen T_{power} is constant and known by the PRx and PTx
  - Maximum time between 2 communication slots ($T_{comm\text{-}lag,max}$)
    - Ensures responsiveness of system, impact design robustness on PRx side
- PTx defined
  - maximum time allowed between 2 FOD slots ($T_{FOD\text{-}lag,max}$)



Slot scheduling – computation (1)

- Ensure that at least one communication and one FOD slot occur per cycle. Results in the two requirements:
  - $T_{comm\text{-}lag,max} > 2 \times T_{power,min}$
  - $T_{FOD\text{-}lag,max} > 2 \times T_{power,min}$
- If the above two conditions are valid then the slot schedule can be computed as follows:
  - Compute the ratio between the communication lag and the FOD lag:
    - time_ratio = $T_{comm\text{-}lag,max} / T_{FOD\text{-}lag,max}$
  - The number of FOD and communication slots per cycle are computed as follows:
    - If time_ratio ≥ 1:
      - # of FOD_slots = time_ratio
      - # of Comm_slots = 1
    - Else:
      - # of FOD_slots = 1
      - # of Comm_slots = 1/time_ratio
  - Total number of slots per cycle (# slots): # of Comm_slots + # of FOD_slots

Slot scheduling – computation (2)

- Knowing the total number of slots one can compute the cycle time
- If $T_{comm\text{-}lag,max}$ and $T_{FOD\text{-}lag,max}$ allow, T_{power} can be maximized
  - $T_{power,max} = max(T_{comm\text{-}lag,max}, T_{FOD\text{-}lag,max}) / \#\ slots$
- Using $T_{power,min}$ and $T_{power,max}$ one can compute the minimum and maximum Cycle time a PTx may use

Examples

Example 1:

```
----- Input parameters -----
T_power_min: 10.00 ms
T_comm_lag_max: 70.00 ms
T_FOD_lag_max: 30.00 ms

----- Results -----
Number of slots per cycle: 4
Number of communication slots per cycle: 1
Number of FOD slots per cycle: 3

The actual power signal duration T_power must be between 10.00 ms and 17.50 ms.
One cycle lasts at minimum 40.00 ms and at maximum 70.00 ms.
>>
```

Example 2:

```
----- Input parameters -----
T_power_min: 20.00 ms
T_comm_lag_max: 50.00 ms
T_FOD_lag_max: 400.00 ms

----- Results -----
Number of slots per cycle: 9
Number of communication slots per cycle: 8
Number of FOD slots per cycle: 1

The actual power signal duration T_power must be between 20.00 ms and 44.44 ms.
One cycle lasts at minimum 180.00 ms and at maximum 400.00 ms.
>>
```

Conclusions

- Proposal of a fixed slot scheduling approach
- Proposal to define three parameters
- Use these parameters for slot scheduling computation
- Proposal to add into the “General Wireless Power Specification”