GUARANTEEING INTEROPERABILITY OF EFFICIENT AND FLEXIBLE WAKE-UP/SLEEP IN A 100BASE-T1 ENVIRONMENT

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1. Typical automotive networks → heterogenous
2. Multiple Ethernet vendors involved
3. Is interoperability guaranteed?
OPEN TC10 Wakeup/Sleep Rational

Pragmatic and fast way of enabling/disabling ECUs

1. Support fast wake-up and wake-up request forwarding to support a global wake-up on layer 1

2. Support controlled link shutdown to hibernate selected parts of network

OPEN TC10
Primitives & Mechanisms
Example Topology

3 Port Switch

Switch

PHY

PHY

PHY

uC

3 Port Switch

Switch

PHY

PHY

PHY

uC

2 Cameras

Transmission ECU / Engine ECU
Sleep over Active Link

Use-case: Switch needs to power-off cameras
Wakeup over passive link

Use-case: Switch wakes up cameras
Wakeup Forwarding over active and passive link (WUP and WUR)

Use-case: Wakeup event at gear selector wakes entire system
Wakeup Forwarding over active and passive link (WUP and WUR)

Use-case: Wakeup event at gear selector wakes entire system

Subsystem in sleep
Sleep Handshake

Sleep Initiator

- loc_sleep_req
- Sleep.indication
- Sleep.indication
- Wakeup.request

Sleep Responder

- Sleep.indication
- Time window to abort sleep

States:
- NORMAL
- REQ
- SILENT
- SLEEP
- NORMAL (link training)
- SLEEP_ACK
- SLEEP_RE
- QEST
- SLEEP
- NORMAL (link training)
Sleep Handshake

Each state is associated with defined timing
→ Interoperability test ensures correctness across vendors
Interoperability
Multi-Supplier-Solutions

- (Mis-)Interpretation is especially a problem in an environment in which products of different suppliers have to interoperate

- One single specified standard can be interpreted differently by different implementers, because:
  - Human language itself is ambiguous
  - A specified standard might contain coverage gaps, missing details
  - The implementer might misunderstand the specification
Wake-up/Sleep IOP Test Suite

Facts and Numbers

- 13 Test cases
- Reflecting in 46 instances
  - Master/Slave, Swapped Polarity, Channel Type

Test Groups

<table>
<thead>
<tr>
<th>Test Group</th>
<th>Number of test cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wake-up reception and signalizing</td>
<td>3</td>
</tr>
<tr>
<td>Wake-up transmission</td>
<td>3</td>
</tr>
<tr>
<td>Wake-up forwarding</td>
<td>5</td>
</tr>
<tr>
<td>Sleep</td>
<td>2</td>
</tr>
</tbody>
</table>
Timing Measurement - Wake-up

**Wakeup over an active link**

- TWU_Link_active
- <1ms

**Wakeup over a passive link**

- TWU_Link_passive
- <2ms
Timing Measurement - Sleep

Local sleep request

- T_LinkSleep
- <16ms

Remote sleep request

- T_LinkSleep
- <24ms
Timing Measurement – Forwarding

Wakeup forwarding integrated

- TWU_Forwarding
- <1ms

Wakeup forwarding via optional I/O

- TWU_WakeIO
- <1ms
Example: Reception of a Wakeup Pulse

Reception of a Wakeup Pulse (WUP)

- TWU_Link_passive + T_Powersupply_Stable + T_PHY_Initialization
- 2ms + 5ms + 10ms
- <17ms
Conclusion

- Wakeup & Sleep over dataline will eventually replace legacy 'wakeup lines'
  - Seamless transition / co-existance possible
- Advanced use-cases: wakeup forwarding
- Scales to other Ethernet physical layers
- Interoperability integrated into OPEN Alliance TC-1 IOP
- Concept specification from OPEN TC10 transferred to ISO 21111-2
- IOP tests will be available from 01/2018
Questions?
BACKUP
Timing Measurement

Power Supply Stable

- $T_{\text{Powersupply\_Stable}}$
- 90% of nominal value
- <5ms

PHY Initialization

- $T_{\text{PHY\_Initialization}}$
- <10ms

![Diagram showing the timing sequence for Power Supply Stable and PHY Initialization]