Beyond the crystal: Innovating ADAS with Simplified Sensor Modules

Contribution to 802.3dm Task Force

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TJ Houck (Marvell)
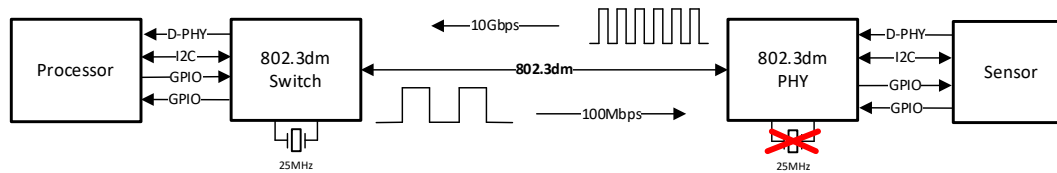**Paul Fuller (Marvell)**
Ragnar Jonsson (Marvell)

Topics

- What is crystal-less operation?
- Advantages of crystal-less operation
- How does crystal-less operation work
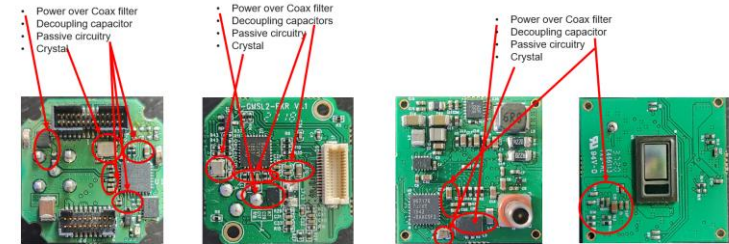- What happens when a clock is not provided

What is crystal-less operation

- Crystal-less operation gives the ability for the PHY on the module sensor to run with **no** crystal.
- Previous ethernet standards require a precise clock from a crystal or oscillator on both sides of the link to maintain accurate data transmission
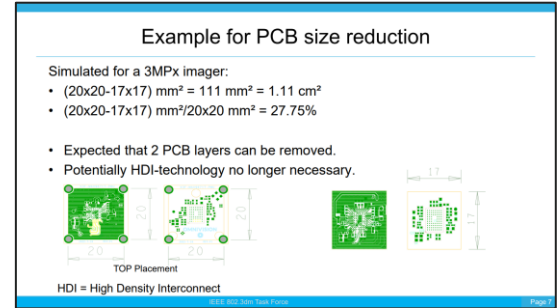

Referenced: https://www.ieee802.org/3/dm/public/0724/houck_3dm_01_0724.pdf

Advantages of crystal-less operation

- Reduced Cost and Component count
  - No crystal oscillator
  - Lower power consumption (removal of crystal)
  - Reduces Camera PCB size
  - Reliability – removal of moving part (oscillator)

- Simplified System design
  - Eliminates the need for synchronization techniques

- Simplified Timing synchronization
  - Using backchannel for clock synchronization ensure both sides of the link are locked to the same timing reference.
    - This could improve overall timing precision and reduce timing discrepancies.

Example for PCB size reduction

Simulated for a 3MPx imager:
- (20x20-17x17) mm² = 111 mm² = 1.11 cm²
- (20x20-17x17) mm²/20x20 mm² = 27.75%

- Expected that 2 PCB layers can be removed.
- Potentially HDI-technology no longer necessary.

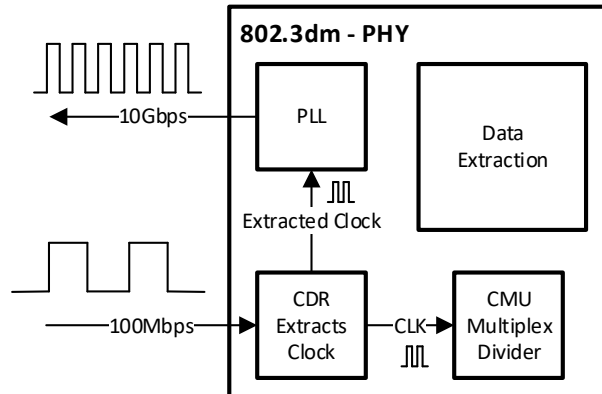TOP Placement

HDI = High Density Interconnect

Referenced: https://www.ieee802.org/3/dm/public/0724/houck_3dm_01_0724.pdf
Referenced: https://www.ieee802.org/3/dm/public/0724/broedel_matheus_dm_01_size_07152024.pdf

How does crystal-less operation work

- The 100Mbps Signal sent to PHY

- Clock and Data Recovery (CDR)
  - The CDR extracts a clock from the 100Mbps continuously transmitted signal.

- Phase Lock Loop (PLL)
  - Used to lock to timing information from the 100Mbps backchannel to generate the required high speed clock for the PHY

- Clock Management Units (CMU)
  - Ensures the appropriate clock frequency is scaled depending on the link speed
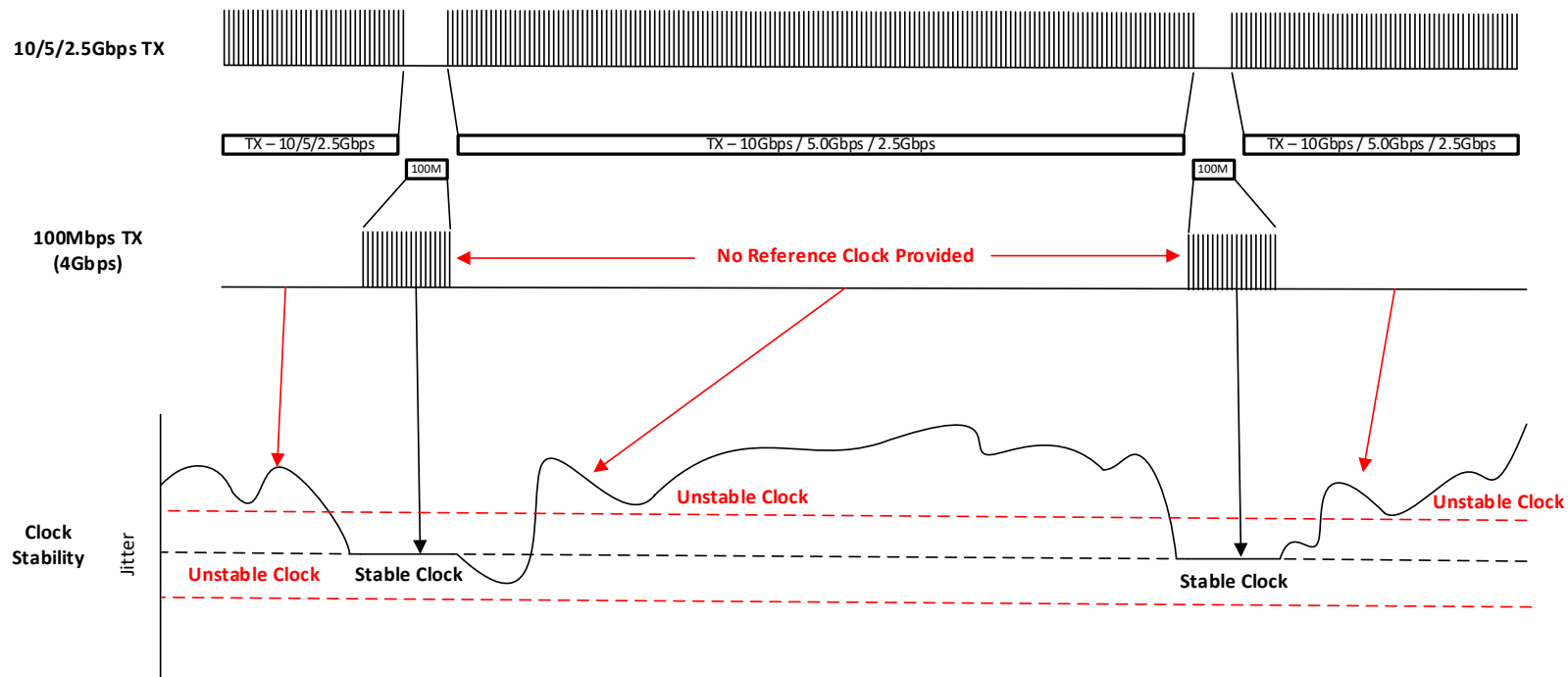
Crystal less operation for Continuous Transmission vs. TDD

	802.3dm 100Mbps (Continuous Transmission)	802.3dm – 4Gbps (TDD)
Operation Type	**Always** Transmitting and Receiving	Time Division Duplex – **Alternating** Upstream and Downstream
Continuous Reference Clock	**Always available**	**Only available during short periodic bursts**
Crystal less Feasible	**Yes**	**No/Possible?**
CDR complexity	**Low** due to 100Mbps	**High** – Difficult to recover low jitter clock from 4Gbps TX
PLL Requirements	**Low** due to 100Mbps	**Feasible?** • PLL needs to handle switching between TX and RX • Unavailable reference clock leads to unstable TX
Jitter Sensitivity	**Low** due to 100Mbps	**High** – Difficult to recover low jitter clock from 4Gbps TX

Summary

1 It is proposed to provide **crystal-less operation** as a critical feature needed for 802.3dm to be competitive in camera module designs

2 It is proposed to provide a **continuous clock reference** to simplify camera modules BOM and cost

3 Do not preclude timing recovery from 100Mbps **without the use of a crystal**