mipi® DEVCON

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MIPI M-PHY® Gear4 and its impact on MIPI UniPort℠/UFS

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MIPI ALLIANCE
DEVELOPERS
CONFERENCE

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Agenda

- MIPI M-PHY
- MIPI UniPro
- UFS

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MIPI M-PHY

- Bursts and Gears
- Gear 4
- New Attributes
  - Min_SAVE_Config_Time_Capability
- ADAPT

Burst States

- **Burst States**
  - Data transmission occurs in BURSTs with power saving states between BURSTs.
  - BURSTs can be transferred in HS-MODE or LS-MODE
  - The Min_SAVE_Config_Time_Capability attribute includes all implementation specific timings required to prepare for the reception of the next BURST after configuration during SAVE.
  - Each BURST starts from the SAVE state for that operating mode, with a transition from DIF-N to DIF-P.
  - After a period of DIF-P called PREPARE, a sequence of 8b10b encoded symbols
  - After the last 8b10b SYMBOL of the BURST either a series of b0s or a series of b1s (TAIL-OF-BURST) is transmitted.
  - A series of equal bits violate 8b10b code characteristics, and indicates whether the M-RX returns to the SAVE state of the current operating mode or enters LINE-CFG.
  - In the case of PWM signaling, the last bit of the sequence is inverted to indicate the end of LINE activity.

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Gears and Rates

- **HS-GEARs**
  - A MODULE in HS-BURST shall only operate at the defined data rate, DRHS.
  - There are two RATE series, A and B, where each step in the series scales by a factor of two
  - RATES are used for Limiting EMI with the Cellular modem.
  - A MODULE that includes HS-MODE shall support both RATEs of a GEAR.
  - A MODULE supporting HS-MODE shall support HS-G1. If a higher GEAR is supported all lower GEARs shall be supported as well.

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Burst and Gears

Table 10 HS-BURST: RATE Series and GEARs

RATE A-series (Mbps)	RATE B-series[1] (Mbps)	High-Speed GEARs
1248	1457.6	HS-G1 (A/B)
2496	2915.2	HS-G2 (A/B)
4992	5830.4	HS-G3 (A/B)

1. *The B-series rates shown are not integer multiples of common reference frequencies 19.20 MHz or 26.00 MHz, but are within the tolerance range of 2000 ppm.*

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MIPI M-PHY Gear4

- Doubling of the Data Rate from HS-Gear3 to HS-Gear4

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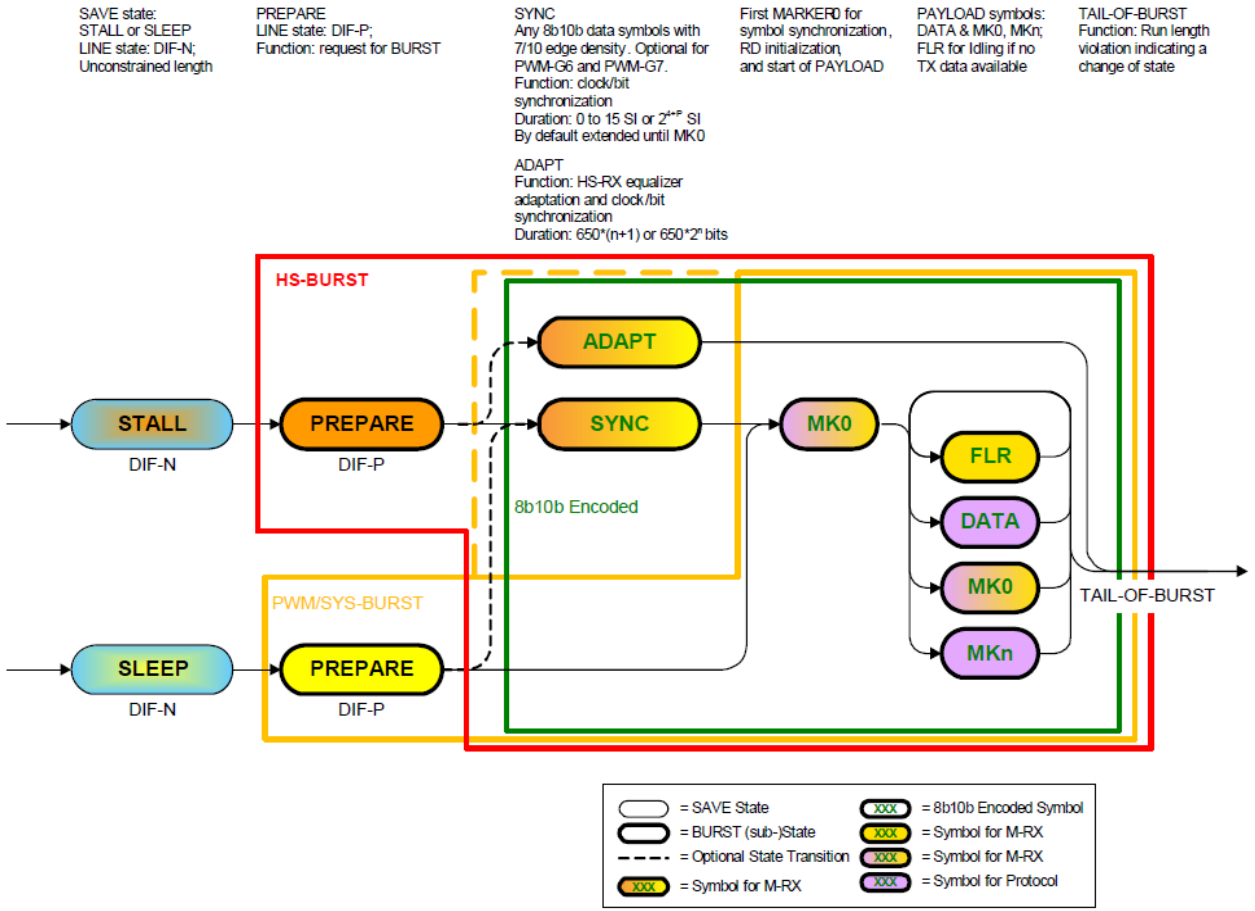
Min_SAVE_Config_Time_Capability

- Min_SAVE_Config_Time_Capability attribute includes all implementation specific timings required to prepare for the reception of the next BURST after configuration during SAVE.
  - Prepare
  - ADAPT
  - Sync



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ADAPT

- **ADAPT**
  - The ADAPT sub-state is intended for the RX equalizer training
  - If an M-RX supports ADAPT, the PREPARE sub-state may be followed by the ADAPT sub-state for HS-G4.
  - ADAPT sequence starts with MK0 followed by an 8b10b encoded PRBS9 pattern
  - ADAPT sequence is completed by one b0 bit.
  - The 8b10b PRBS9 ADAPT sequence repeats every 650 bits.
  - ADAPT sub-state ends with the transmission of a TAIL-OF-BURST
  - M-RX and M-TX shall return to the STALL state.

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ADAPT

- During initial discovery, the local protocol requests and reads capabilities of MODULEs on both sides of the LINK.
- If HS-G4 equalizer capability is detected on both sides, updates the remote M-RX ADAPT length capability into its local M-TX ADAPT length configuration.
  - TX_HS_ADAPT_Length >= RX_HS_ADAPT_INITIAL_Capability
- The local protocol shall update the following setting for a Refresh ADAPT:
  - TX_HS_ADAPT_Length >= RX_HS_ADAPT_REFRESH_Capability
- When a HS-G4 BURST is initiated and ADAPT has been configured the M-TX transitions from PREPARE to the ADAPT sub-state instead of SYNC.
- The M-TX transitions from DIF-P to transmitting the ADAPT sequence.
- Both M-TX and M-RX remain in the ADAPT sub-state for the equalizer training for a duration of *T*ADAPT
- The M-RX signals exit from the ADAPT sub-state by flipping the ADAPT_Control field of RX_ADAPT_Control from ADAPT to SYNC and returning to STALL.

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MIPI UniPro 1.80

- New Link Startup Sequence
- PACP Changes
- Burst and Deskew
- Quality of Service
- New Primitives
- Deprecated Functions

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Changes to Link Startup

- Terminating a Link Startup
- A UniPro Link Startup Sequence shall be aborted without reporting PA_LM_LINKSTARTUP.cnf_L(FAILURE) to the DME by either of the following conditions:
  - Local Application setting Power Mode to Hibernate_Mode or Off_Mode
  - Local Assertion of UniPro Cold Reset or UniPro Warm Reset

- Error Processing during Link Startup
- During Link Startup, the PA layer can only advance the Link Startup Phase
  - even when receiving errors on the incoming Link.
- The PA Receiver should advance from Phase 0, Phase 1 or Phase 3 upon receipt of the correct TRG Symbols
- The PA Receiver should ignore errors received during Phase 0 through Phase 4.
- A PA_LM_LINKSTARTUP.cnf_L(FAILURE) should only be generated from a timeout.
- HIBERN8 immediately after PA_LM_LINKSTARTUP.cnf_L(FAILURE), to prepare for a new Link Startup 1792 attempt from the local DME or the peer Device.

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PACP Changes

- Gear 4
  - PACP_PWR-REQ/CNF
    - Added value of 4 in the TX/RXGear field
- Adapt
  - PACP_PWR-REQ/CNF
    - This field indicates the presence of ADAPT and type of ADAPT range (Fine or Course) selected for the current Power Mode Change
- PACP_CAP_ind
  - MaxHS
    - This field shall be ignored by the PA receiver if PACP_CAP_EXT2_ind is received.
    - Instead, the MaxHS field of PACP_CAP_EXT2_ind shall be used.
    - If TX_HSGEAR_Capability is returned with value 4 or above, the PA transmitter shall set this field with value 2b'11
    - In all other cases, the PA transmitter shall set this field with the value retrieved from TX_HSGEAR_Capability[1:0].

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PACP Changes

- **PACP_CAP_EXT2_ind**
  - The PACP_CAP_EXT2_ind frame is new
  - It supports all new capabilities introduced in M-PHY specification revision 4.0 onwards.
  - It is used in phase 5 of Link Startup Sequence before the PACP_CAP_EXT1_ind to notify the peer PA Layer of the local M-TX, M-RX, and PA Layer capabilities
  - Legacy Devices prior to UniPro version 1.8 not being able to recognize PACP_CAP_EXT2_ind shall
  - discard the reception of those PACP frames and proceed to PACP_CAP_EXT1_ind or PACP_CAP_ind
  - The frame's fields are as follows
    - MaxHS: Maximum HS gear, or zero if HS mode is unavailable
      - This field overrides the field with the same name that is found in PACP_CAP_ind frame.
    - RxHsG4SyncLength: M-PHY timing information
    - RxHsG4PrepareLength: M-PHY timing information
    - RxHsAdaptInitial: M-PHY timing information
    - RxHsAdaptRefresh: M-PHY timing information
  - Unsupported or non-existing M-PHY capability attributes are reported with every bit set to '1'.

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Power Mode Changes

- **With MIPI UniPro Version 1.8 Only**
- Local PA Layer sends a PACP_PWR_req frame
- When the remote PA Layer receives a valid PACP_PWR_req frame
- The remote PA Layer shall send the PACP_PWR_cnf frame.
- The local PA Layer receives a valid PACP_PWR_cnf frame
- It checks the Status field.
  - If the Status field contains PWR_OK, PAPowerModeUserData is passed to the local DME.
- The local PHY Layer wil be configured with the requested parameters.
- The local PA Layer shall close the burst on the outbound Link.
- The remote PA Layer shall close the burst on the other Link when detecting the end of burst on its inbound Link.

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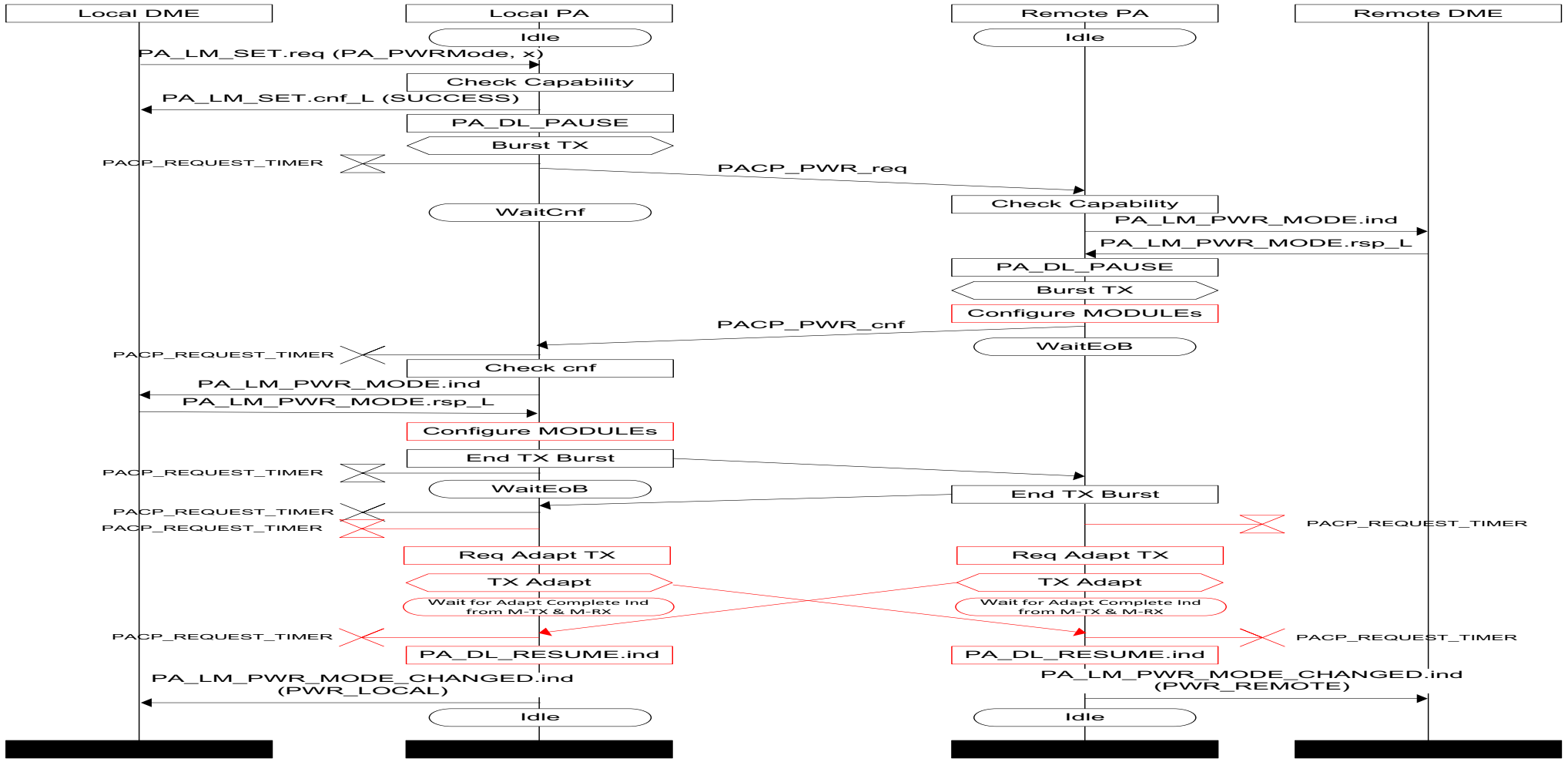
Power Mode Change with Adapt



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Burst Start and Deskew Pattern

Burst Start and Deskew Pattern

- An M-PHY burst shall begin by transmitting a deskew pattern <MK0, MK1>,
- MK0 functions as an Start of Burst HEAD-OF-BURST marker.
- The deskew pattern is also used when resynchronizing Lanes
- The deskew pattern shall be transmitted simultaneously on all active Lanes.
- The deskew pattern may be transmitted at any point in time for the purpose of potential error recovery

- **Dummy Burst**
- A dummy burst is an M-PHY burst that is sent on inactive M-PHY Lanes in a Multi-Lane scenario during Link configuration.
- A dummy burst is to synchronize the M-PHY Lane attributes across both, inactive and activated Lanes
- A dummy burst does not carry any payload and is not used in Lane distribution
- A dummy burst is issued only on Lanes with a logical Lane number greater than 0.
- The dummy burst shall begin by transmitting a special pattern <MK0, FLR>, which distinguishes the dummy burst from a normal burst. During the dummy burst, the PA Layer shall send only FILLERs.

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New Primitives

- PA_INIT.ind
  - Informs the DL Layer that there was a PA_INIT requested by the Peer PA Layer. The DL Layer should notify the DME
- PA_LM_RX_SYMBOL_CNT.ind
  - PA Layer generates this primitive every time it receives 1024 Symbols between the Head of Burst and the End of Burst
- PA_LM_TX_SYMBOL_CNT.ind
  - PA Layer generates this primitive every time it transmits 1024 symbols between between HoB and EoB
- M-LANE-AdaptStart
- M-LANE-AdaptComplete
- M-LANE-MRXSaveState
- M-LANE-AdaptComplete

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MIPI UniPro Deprecated Functions in 1.80

- **T-MPI**: T-MPI avoids excessive pin-counts by utilizing high-speed SERDES technologies found in modern FPGAs.
- **LCC:** LINE Control Command (LCC)
- Basic Optical Media Converters are supported as optional
- Advanced Optical Media Converters are not supported as options.
  - UniPro does not mandate the implementation of the M-PHY state LINE-CFG, nor does UniPro make use of the LINE-CFG state, should it be part of the M-PHY implementation.
- UniPro specification Version 1.80 gives up backward compatibility to UniPro Versions v1.41.00 and earlier. Specifically due to deprecation of LCC

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UFS

- **General Features**
  - Target performance
  - High speed GEARs
    - Support for GEAR1 is mandatory
    - Support for GEAR2 is mandatory
    - Support for GEAR3 is optional
    - Support for GEAR4 is mandatory

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UFS Data Rates and Clock considerations

6.4.1 HS Gear Rates

Table 4-1 defines the data rate values for the two rate series with respect REF_CLK frequency value (fref).

Table 4-1 — HS-BURST Rates

HS-GEAR	Rate A-series	Rate B-series		Rate A-series (from [MIPI-M-PHY])	Rate B-series[4] (from [MIPI-M-PHY])	Unit
	f_{ref}	f_{ref}		f_{ref}	f_{ref}	
	19.2 / 38.4 / 26 / 52	19.2 / 38.4	26 / 52	19.2 / 38.4 / 26 / 52		MHz
HS-GEAR1	1248[2]	1459.2	1456.0	1248	1457.6	Mbps
HS-GEAR2	2496	2918.4	2912.0	2496	2915.2	Mbps
HS-GEAR3[3]	4992	5836.8	5824.0	4992	5830.4	Mbps
HS-GEAR4	9984	11673.6	11648.0	9984	11660.8	Mbps

NOTE 1 "Mbps" indicates 1000000 bit per sec.

NOTE 2 1248Mbps with fref = 38.4 MHz may be obtained using a prescaler. fref * M /P, M = 65 (PLL multiplier), P = 2 (Prescaler).

NOTE 3 Support for HS-GEAR3 is optional.

NOTE 4 The B-series rates shown are not integer multiples of common reference frequencies 19.2 MHz or 26 MHz, but are within the tolerance range of 2000 ppm.

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UFS HS Burst

- **UFS HS Burst**
  - A UFS device shall support the HS-GEAR1, HS-GEAR2 and the HS-GEAR4.
  - Support for HS-GEAR3 is optional.
    - This violates the M-PHY spec which states that all lower gears must be supported.
  - SUBLINKS in a LINK may communicate with different HS-GEAR or PWM-GEAR.
- **HS Prepare Length Control**
  - The TX_HS_PREPARE_LENGTH M-PHY configuration attribute defines the time to move from STALL to HS-BURST. At reset, M-TX sets TX_HS_PREPARE_LENGTH = 15.
- **HS Sync Length Control**
  - The TX_HS_SYNC_LENGTH M-PHY configuration attribute defines the number of synchronization symbols before a HS Burst.
  - In the UFS interface the synchronization sequence shall be generated by the M-TX.
  - Support for protocol controlled synchronization is optional.
  - M-TX starts at reset with TX_HS_SYNC_LENGTH = 15, in COARSE type.

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- **PWM Burst**
- A UFS device shall support the PWM-G1 (default, mandated by [M-PHY]), PWM-G2, PWM-G3 and PWM-G4 GEARS.
- The PWM-G5, PWM-G6 and PWM-G7 are optional.
  - Even if the physical layer supports PWM-G0, this gear can not be used because it is not supported by UniPro
- The PWM-G1 is the active gear by default after power up or reset.
- SUBLINKS in a LINK may communicate with different PWM-GEAR or HS-GEAR.

- **LS Prepare Length Control**
- The TX_LS_PREPARE_LENGTH M-PHY configuration attribute defines the time to move from SLEEP to PWM-BURST.
- At reset, M-TX sets TX_LS_PREPARE_LENGTH = 10.

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