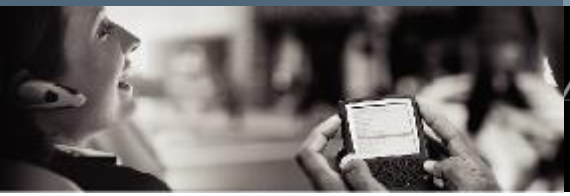
T_{droop} vs. Inductor Size and Cost for PoDL

Andy Gardner

July 2014



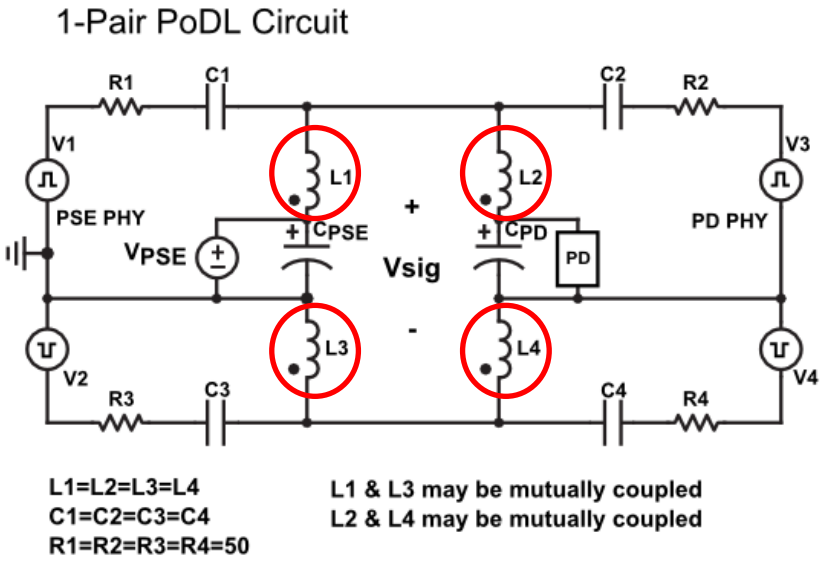
LINEAR TECHNOLOGY

PoDL Decoupling Inductors

- 1-pair PoDL relies upon decoupling inductors at the PSE and PD to allow both power and data to be delivered over the same twisted pair.
- The size of the inductors is constrained by the T_{droop} specification for the PHY:

$$L \geq \frac{-50ohms \times t_{droop}}{\ln(1 - 0.269)}$$

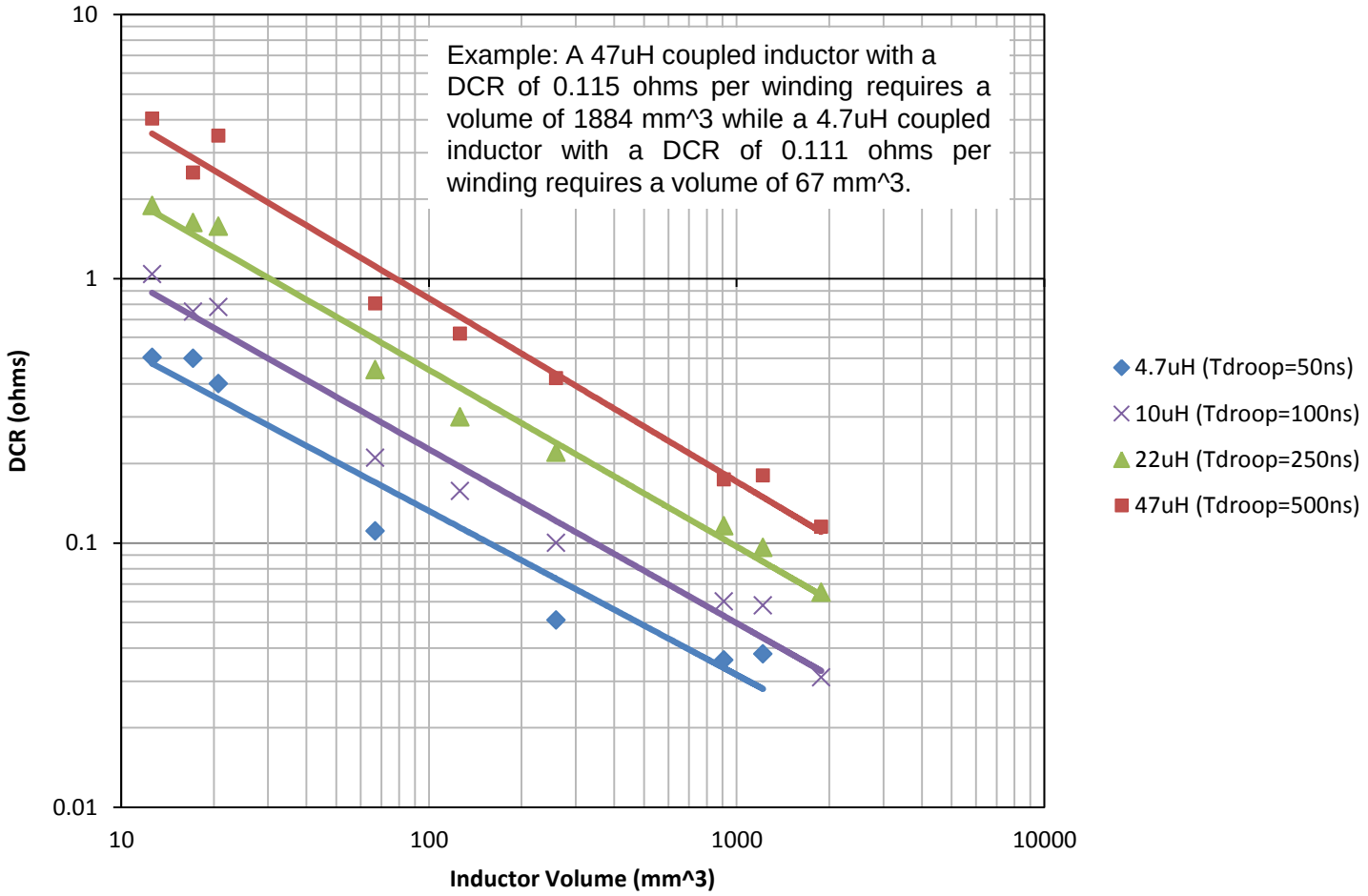
- The source and return inductor pairs at the PSE and PD will likely be mutually coupled in order to conserve core material, improve matching, and multiply effective inductance by 2.
- Unlike POE where the net core flux of the magnetics is cancelled by the flow of DC current, the net core flux of mutually coupled inductors in PoDL is additive.
  - Inductor saturation current has to be significantly greater than the PD's maximum operating current in order to guarantee that the T_{droop} specification is always met.



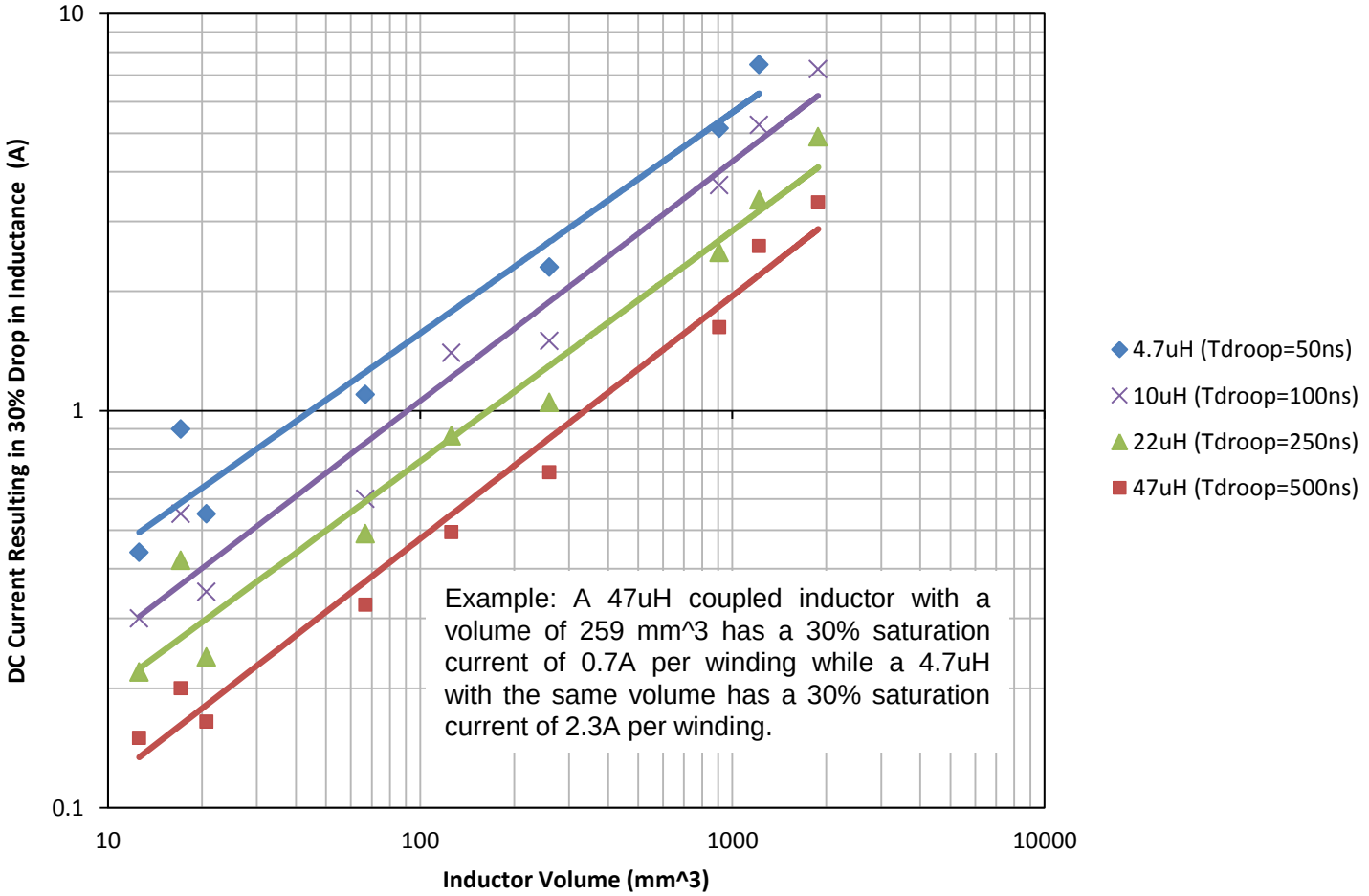
What is the Impact of T_{droop} on the PoDL Inductors?

- Data for a range of coupled inductor package sizes was collected from Coilcraft.
  - Data trends from Coilcraft coupled inductors were found to correlate closely with another major vendor of coupled inductors.
- The following metrics were considered when attempting to determine the total inductor ‘cost’ as a function of T_{droop}:
  - DCR vs. volume
  - Saturation current vs. volume
  - SRF vs. volume
  - Relative Cost vs. volume

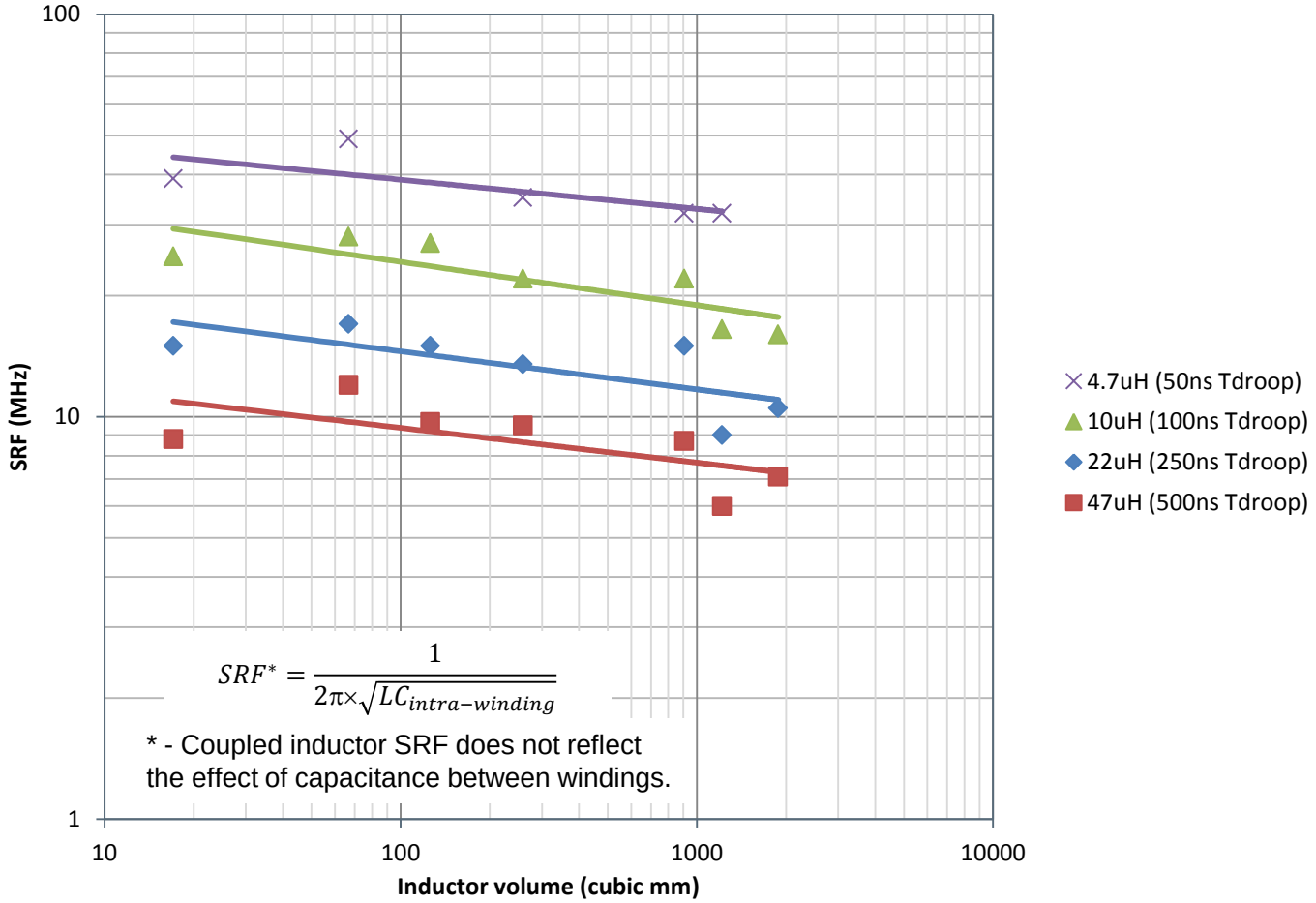
Coupled Inductor DCR vs. Volume



Coupled Inductor Saturation Current vs. Volume

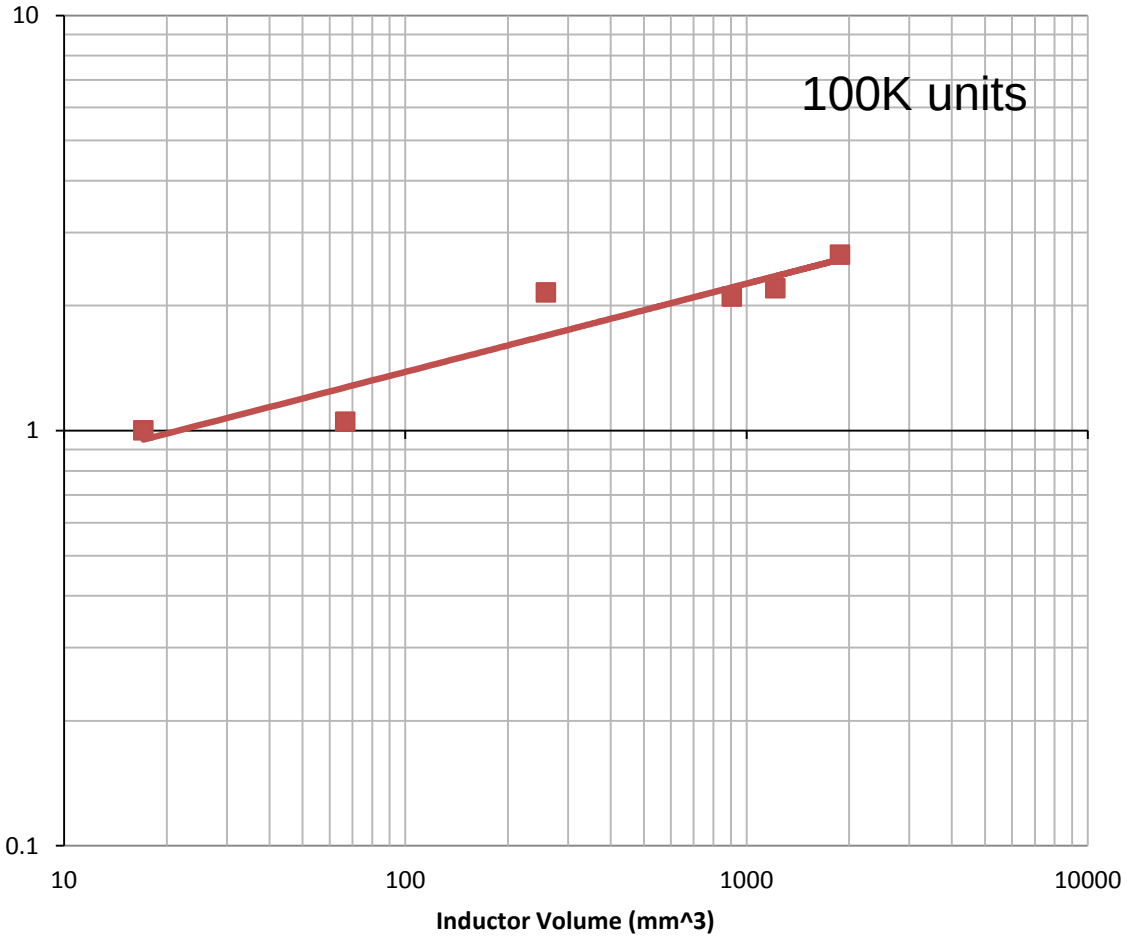


Coupled Inductor SRF vs. Volume



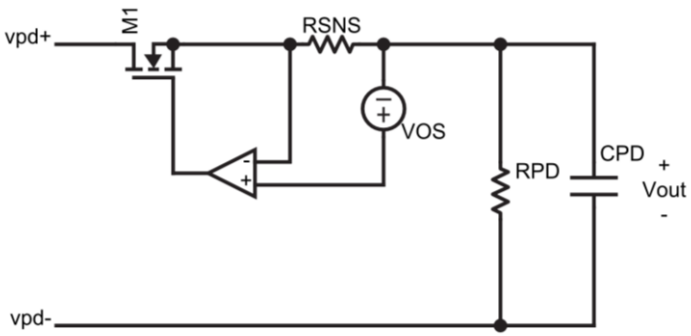
LINEAR TECHNOLOGY

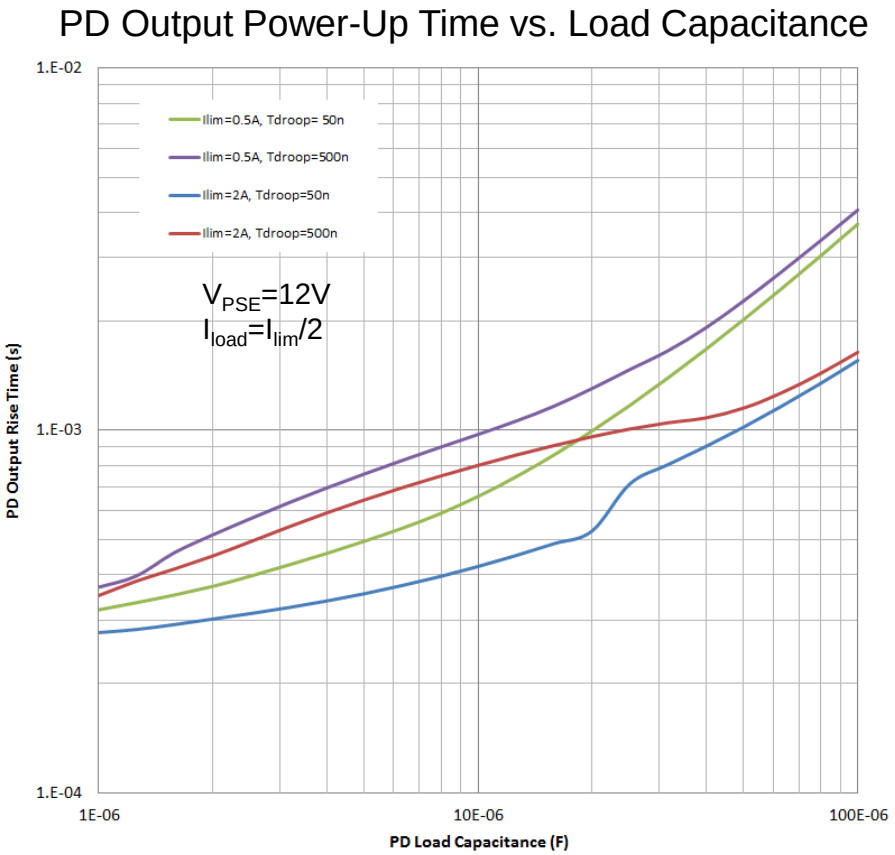
Relative Coupled Inductor Cost vs. Volume



Effect of T_{droop} on PD Output Power-Up Time

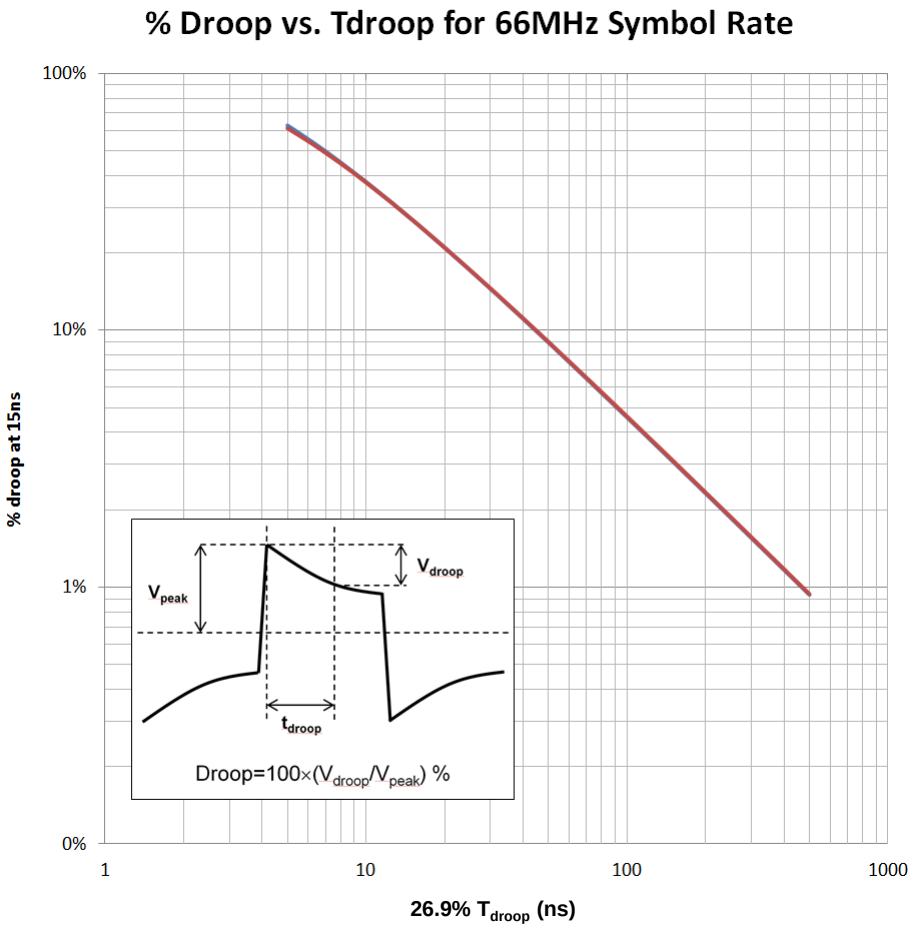
- PD power-up time was simulated with a current limited switch.
- T_{droop} was observed to have a modest impact on PD power-up time.





Impact of T_{droop} Specification on PHY SNR

- Droop within a symbol period results in a reduction in PHY SNR.
- For a 100Mbps data rate, the symbol period is ~15ns, i.e. 66MHz baud rate for PAM3.
- The current 26.9% T_{droop} specification of 500ns results in ~0.9% reduction in PHY voltage after 15ns.
- A 26.9% T_{droop} specification of 50ns would result in ~9% reduction in PHY voltage after 15ns.



Conclusions

- There is a significant volumetric cost associated with the PoDL decoupling inductors as PD operating current requirements increase beyond 1A.
- Relaxation of the Tdroop specification may be warranted in order to ease the burden on the PoDL decoupling inductors at the expense of PHY SNR.

Questions to RTPGE/1TPCE

- Will you accept a Tdroop spec of 50ns (4.7uH) to accommodate practical low physical volume coupling inductors?
  - Tdroop of 500ns with 26.9% droop corresponds to ~47uH.
  - If no, why not?
- Is it possible to choose a Tdroop spec that is uniform between 1000BASE-T1 and 1TPCE to enable rate auto-negotiation with PoDL powered links?
  - Is a higher value of Tdroop worth the additional cost to the PoDL coupling inductors?