TestConX™

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Turbo Charging Active Laser Trim for Precision & Throughput Optimization

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What problem are we trying to solve here?

- Active laser trimming delivers maximum precision with a trim methodology that consumes very little (or no) die area.
  - **Sign me up for that!**
- Optimizing the trim settings to optimize throughput (it is not fast) and precision is device specific and far from easy.
  - **Well we knew there had to be a catch somewhere.**

Can we make that optimization quicker/easier without sacrificing the precision?

Active Laser Trim Cliff Notes – 1 of 4

Laser Trimming

Off-Line Laser

- Trim & Test are separate manufacturing steps.
- Trimming needs to be very fast to be cost effective.
- Ex: Memory Repair
- Ex: Probe - Trim - ReProbe

On-Line Laser

- Trim & Test are combined into a single manufacturing step.
- Trimming needs to be well integrated with the tester.
- Ex: Precision resistors
- Ex: Probe with integrated trim

Active Laser Trim Cliff Notes – 2 of 4

On-Line Trimming

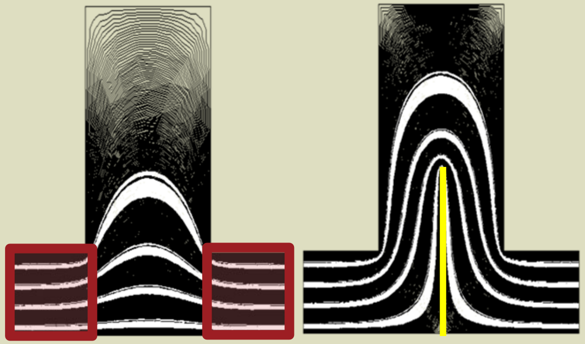
Link Trims

- Fuses or Links like Off-Line trimming
- Trim weight per fuse/link is not predictable enough to create the trim code map required by Off-Line.

Active Trims

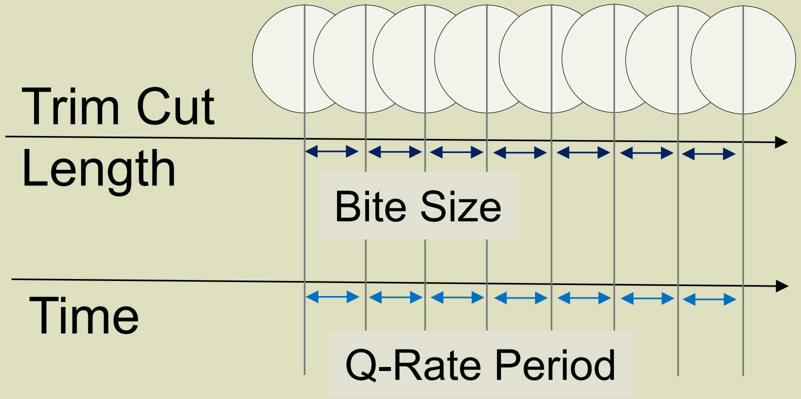
- Almost always a resistor.
- Trims have significant variation.
- Trim result is measured between every laser blast.
- Decision to execute/stop the next laser blast is made just before the next laser blast.

Active Laser Trim Cliff Notes – 3 of 4

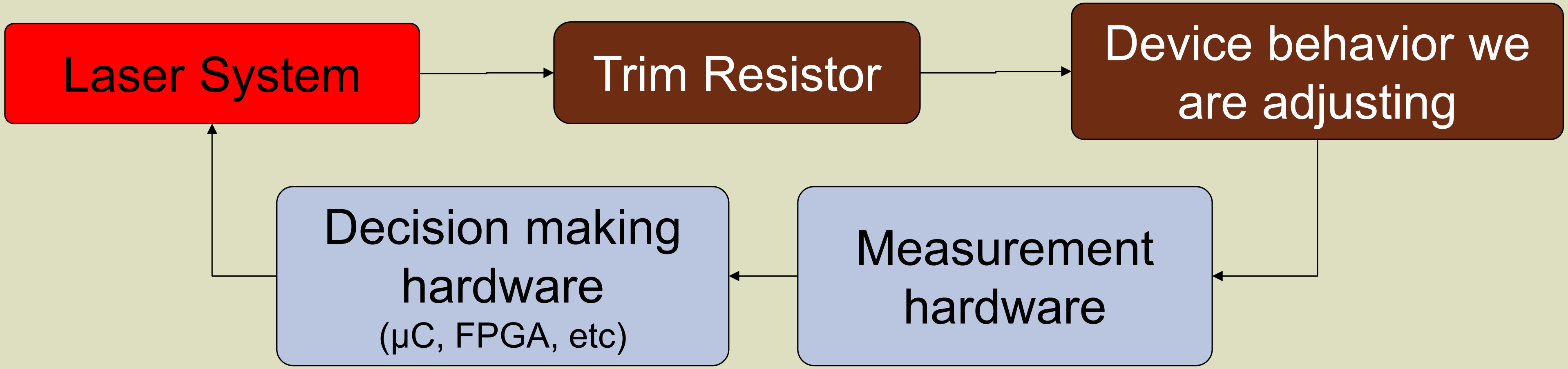


Bite Size:	Larger	– coarser trim, but faster
	Smaller	– finer trim, but slower
Q-Rate:	Faster	– less time for feedback loop
	Slower	– more time for loop to stabilize

Trim is achieved by making a series of overlapping laser blasts in a resistor to divert current flow into a longer path, increasing the effective resistance



Active Laser Trim Cliff Notes – 4 of 4

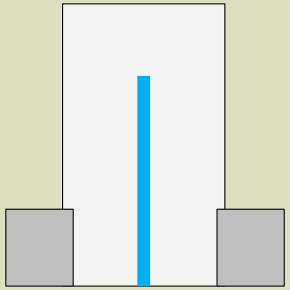


- We go around this loop for every laser blast of the trim.

Where can we optimize Bite Size & Qrate?

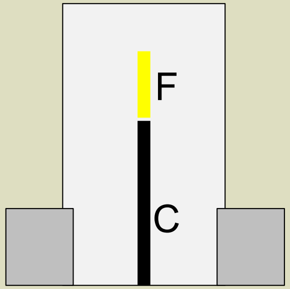
- Remember: Trim speed and precision are inversely proportional to each other.
  - Fine precision = smaller bite sizes = slower trims
  - Faster trims = larger bite sizes = worse precision
  - All of this is relative and the magnitude and slope of the relationships are device specific
- Bite Size: Optimization ability is limited.
  - Combination of datasheet parameters and IC design dictates the bite size at the end of the trim.
  - The test engineer has to determine a bite size that provides the required final precision.
- Q-Rate: Optimization ability is even more limited.
  - The test engineer will typically run this as fast possible, minus a little of bit of margin, that keeps the trim loop stable.

Optimizing Bite Size – How people do it today



No Optimization

- Trim the *entire* feature at the bite size required for the final precision
- Pros: Easy to setup for a beginner user. This is the simplest trim method available.
- Cons: Worst test time



Coarse/Fine Optimization

- Split the feature into two legs.
- Coarse Leg: Larger bite size to save test time at the beginning of the trim.
- Fine Leg: Smaller bite size for the required precision at the end of the trim.
- Pros: Less test time.
- Cons: Much more complicated to set up even for an experienced user. Every device will be different. Adds overhead in the trimmer to execute two legs vs one.

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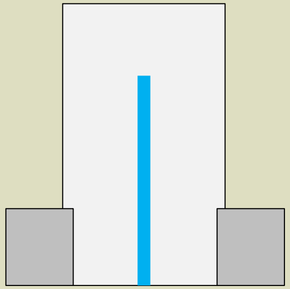
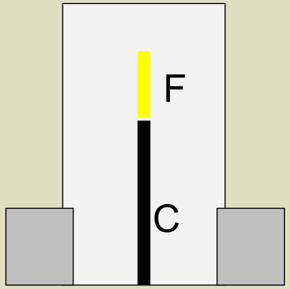
Optimizing Bite Size – Let us Turbocharge it!



No Optimization

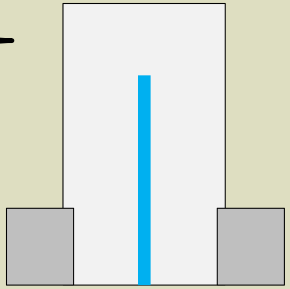
- Simple to create recipe
- Slow to execute in production



Coarse/Fine Optimization

- Pain to create recipe
- Faster to execute in production

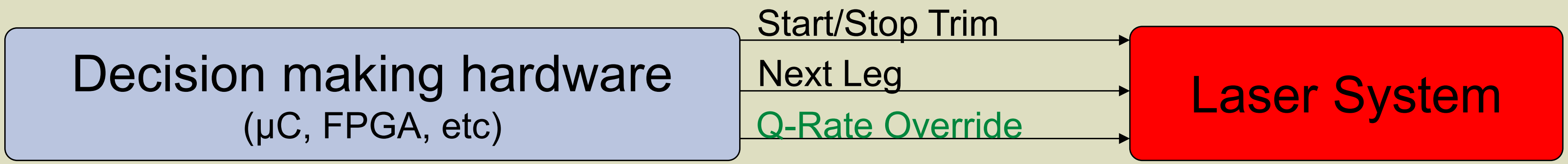
Add a new control signal *(Q-rate Overide)* to gain the benefits of the two trim methods while avoiding the costs.



Turbo Mode

- Patent Pending
- Same simple to create recipe
- *Applies a Q-Rate override* at the beginning of the trim
  – 10 kHz opposed to say 2 kHz.
- Uses the default Q-Rate and Bite Size at the end of the trim to achieve the required precision.

Control lines for Turbocharging the trim



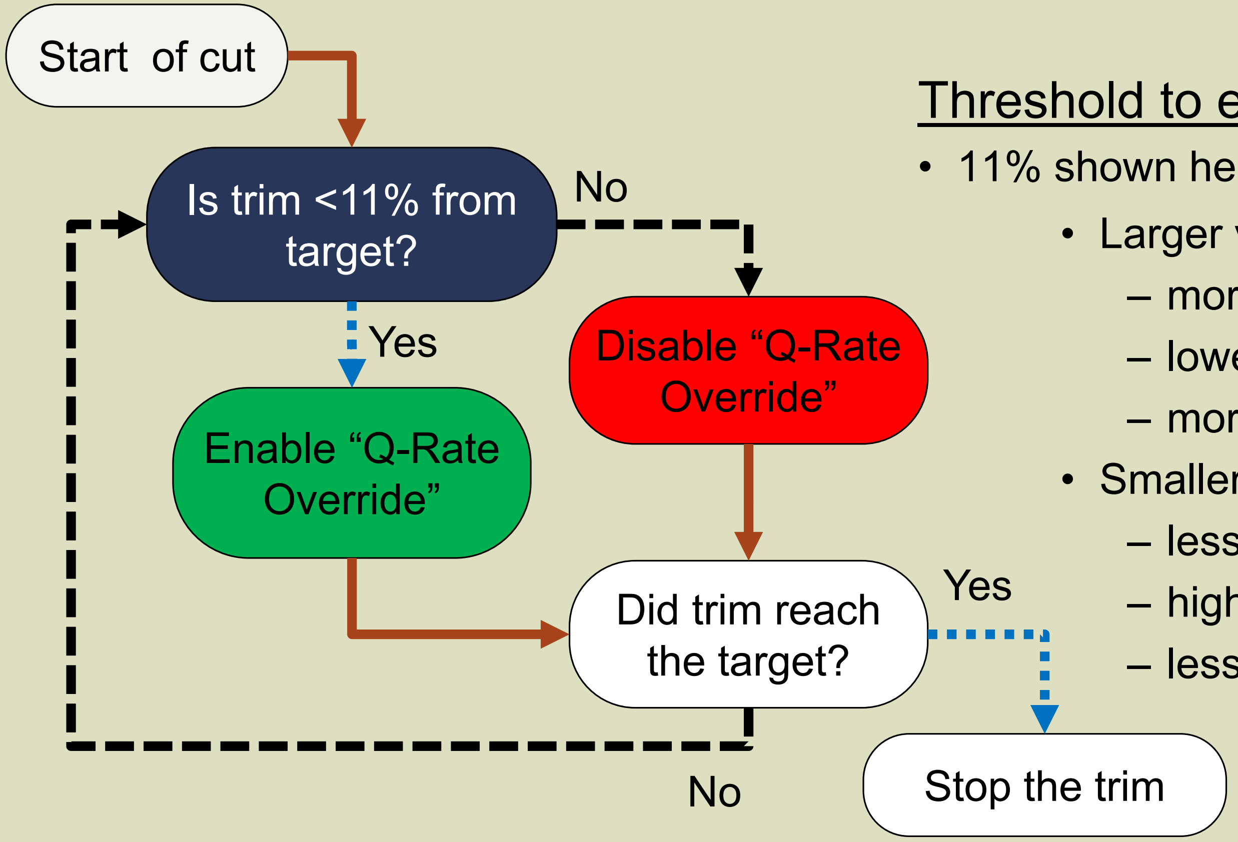
Standard trimmer control signals

- Stop Trim: Tells the trimmer to stop the cut when the target result has been achieved.
- Next Leg: Tells the trimmer to jump from the course to fine leg.

New trimmer control signal

- Q-Rate Override: Tells the trimmer to use a much faster Q-rate while the control is active.

Control block diagram for Turbocharging the trim



Threshold to enable/disable Q-Rate Override

- 11% shown here as an example.
  - Larger value
    - more of trim executes at recipe settings
    - lower risk of disabling too late & overshoot
    - more trim time overall
  - Smaller value
    - less of trim executes at recipe settings
    - higher risk of disabling too late & overshoot
    - less trim time

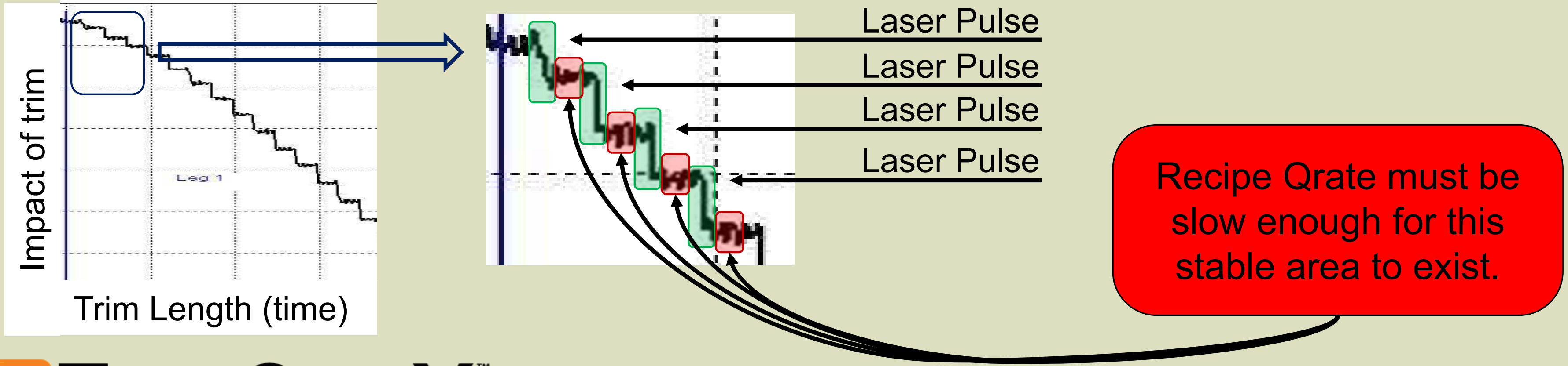
So why not just trim faster all the time?

- This is a lot of effort to dynamically use a faster Qrate for part of the trim.
  - New control input on the trimmer
  - New output on the tester integration (that measures the trim impact and controls the trimmer).
  - New firmware on the tester integration to determine when to enable/disable Turbocharging.
  - User training
- Wouldn't it just be simpler to use the maximum Qrate all the time in the recipe?

- In reality, everyone already uses the maximum Qrate all the time in the recipe.
  - that is stable
  - Remember, active laser trimming has a real-time control loop around the trimming operation.
  - The trim impact is measured between every laser pulse to know when the target is reached.
  - This loop (Trimmer + device + trim impact + measurement + decision making) can only run so fast.

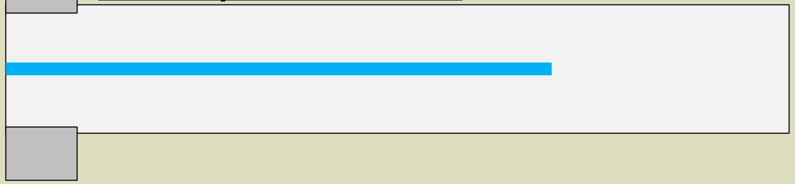
Trading trim stability for trim speed.

- Turbocharging uses a Q-Rate that is much faster than the recipe.
  - For example: Turbocharging at 10 kHz compared to normal trimming at 2 kHz.
- Turbocharging trims so fast that the real-time control loop is not accurate.
  - We stop <11% (again, an example) short of the final target because we are not accurately measuring the trim value while moving this fast.
  - We need some amount of trim range for the loop to stabilize to achieve a precise final result.



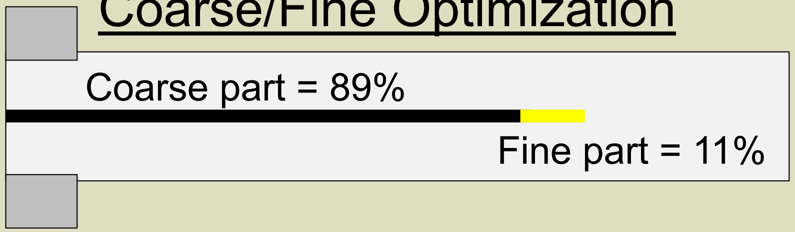
Results with Turbocharging the trim

No Optimization



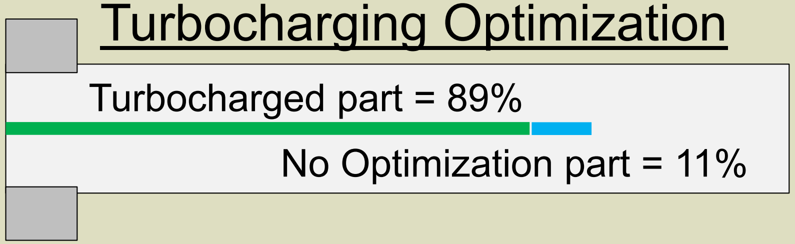
- Trim length: 225 microns
- Bite Size for final precision: 1 micron
- Qrate: 2 kHz
- Total trim time: 113 milliseconds

Coarse/Fine Optimization



- Coarse Bite Size: 2 microns (2x)
- Fine Bite Size: 1 micron (no change)
- Overhead to use a second cut: 2.5 milliseconds
- Total trim time: 65 milliseconds (-42%)
- **Quite tedious to optimize and unique for every product.**

Turbocharging Optimization



- All recipe settings: no changes from simple baseline version
- Overhead to use the TurboCharge 2.5 milliseconds
- TurboCharge Qrate: 10 kHz
- Total trim time: 35 milliseconds (-69%)
- Uses the simple recipe with a better control system.

Turbocharging an active laser trim - Conclusions

You can have your cake, with icing, and eat it too.

- “Cake” An active laser trim recipe that uses one bite-size per feature and one cut per feature. Easy to create. Will always work with stable yield and precision.
- “Icing” You can use that recipe for early customer samples *and* final production.
- “Eating it too” The trim speed can be significantly improved via control automation without a tedious optimization procedure for every device