Lessons learnd from

recent support actions for
LG PRI / LG Electronics

Restrospective Session

*with the focus on the potential for **improvement***
NOT on the criticism and accountability for mishaps

Retrospective Session

Recap of support responsibilities' scope

ShinHoTek: Scan head, RTC, f-theta objective, mounting kit, and correction file
+ advice for the appropriate usage of RTC functions, in particular, laser control functions (with the support from SCANLAB)

PRESTO SOLUTION: Stage motion controller and other accessories related to motion control
+ advice for the appropriate usage of sync*AXIS* functions (with the support from SCANLAB)

SCANLAB: Empowerment of SL Distr. and PRESTO by supplying info materials and offering training sessions

Info materials providing the basic knowledge and reminder of points subject to clarification with the customer

a) Questionnaires for XL *SCAN* Applicability Check
b) Checklist with Preparation Guideline for Installation and Initial Operation of XL *SCAN*
c) sync*AXIS* Installation Manual
d) sync*AXIS* Configurator Manual
e) sync*AXIS* Viewer Manual
f) excelli*SCAN* manual
g) sync*AXIS*-DLL – Application Programming Interface Manual
h) RTC6 Manual

Please at least read through a) – f) and try to understand and remember the relevance of the contents in these documents. In every support case, the points stated in b) checklist shall be checked through with the customer thoroughly. To rule out the doubts about "trivial error sources", please engage **pro-actively** in these actions.

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BUT FIRST and FOREMOST

- **Pro-active** engagement in the external communication with the customer
  => to understand the customer's problem and requirements

- **Pro-active** engagement in the internal communication among SL Distr., PRESTO, and SCANLAB
  => to analyze the customer's problem, devise a suitable solution, and plan support actions

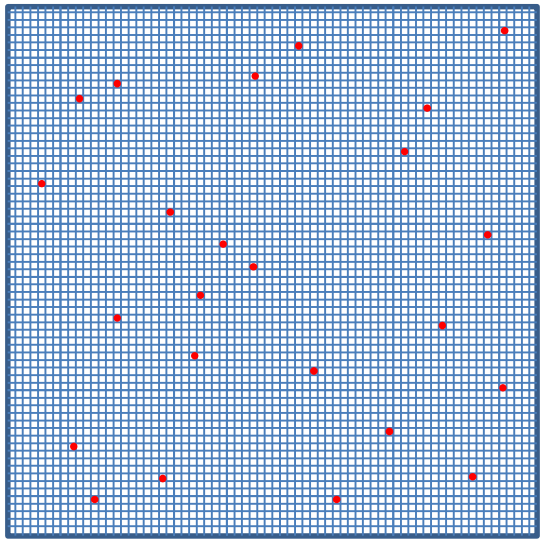
- **Conjoint support as a TEAM** with actions well-organized and well-coordinated among SL Distr., PRESTO, and SCANLAB
  => to actually solve the customer's problem

Technical details, challenges, and trouble shooting

Technical details, challenges, and trouble shooting

Application: Not clearly communicated from customer
Our conjecture => µLED display (sub-)pixel repair ???

Marking pattern: UV laser (WL = 343 – 344 nm) spot array of irregular position distribution
Each spot to be generated by one single shot of laser pulse (spot size: 2 – 3 µm @ FL = 48 mm)
Typical distances between two neighboring spots vary from 0.1 µm up to 13 µm @ FL = 48 mm
FoV size: 6 mm x 6 mm @ FL = 48 mm
Total processing area: 300 mm x 300 mm



schematic depiction of spot array inside a lattice struture of substrate (dimensions not true to scale)

Required pos. accuracy: ± 1 µm ~ ± 2 µm (according to later communication with customer)
(for total system) ± 0.5 µm (according to the questionnaire filled in by customer)

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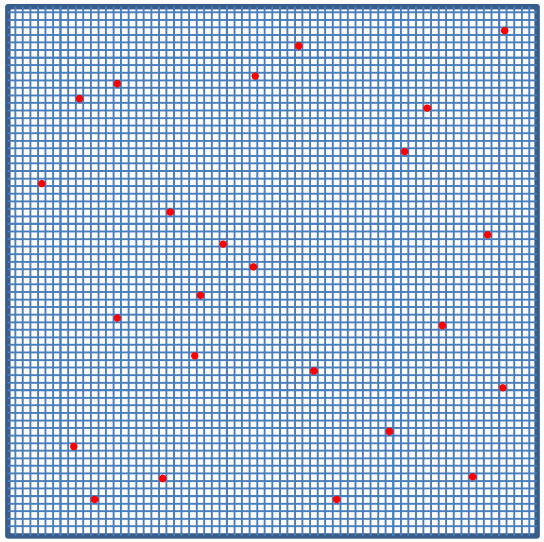

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⇦ **extreme challenge !!!**

Laser: Femto-to-picosec. pulse laser Amplitude Satsuma (max. power: approx. 20 W)
Lumentum PicoBlade was the prev. choice according to the questionnaire filled in by customer.

Stage:

max. travel range:	300 mm x 300 mm
max. speed:	800 mm/sec.
max. acceleration:	approx. 2 G
Load weight:	100 kg for X-axis and 50 kg for Y-axis

Operation modes: A) XL *SCAN* mode with sync*AXIS*.dll
B) FLY mode with RTC6.dll from emulated encoder signals from LCI

Technical details, challenges, and trouble shooting

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⇦ **extreme challenge !!!**

Technical details, challenges, and trouble shooting

Required pos. accuracy: ± 1 µm ~ ± 2 µm (according to later communication with customer)
(for total system) ± 0.5 µm (according to the questionnaire filled in by customer)

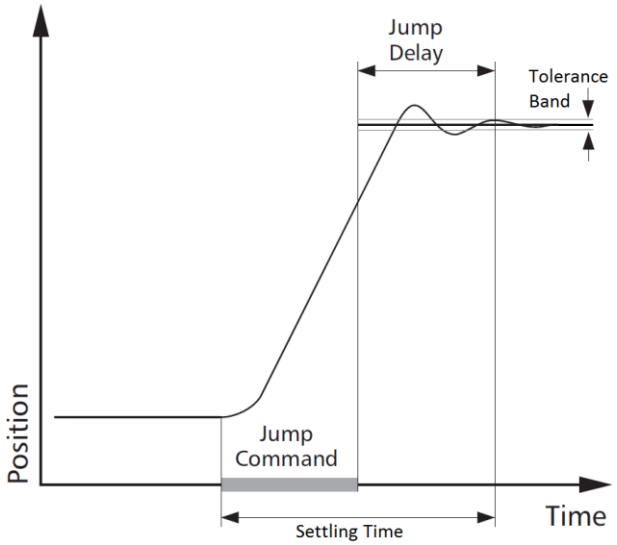
⇦ **extreme challenge !!!**

Customer's approach: Jump-Stop-Shoot Pattern
=> Problem: sudden deceleration to stop the motion leads to large overshoot and long-lasting vibration

=> **Achieved accuracy: ± 5 µm ~ ± 10 µm** at best (under optimal conditions / setting)

high-speed jump
with large acceleration

full stop at target pos.
with large deceleration



Technical details, challenges, and trouble shooting

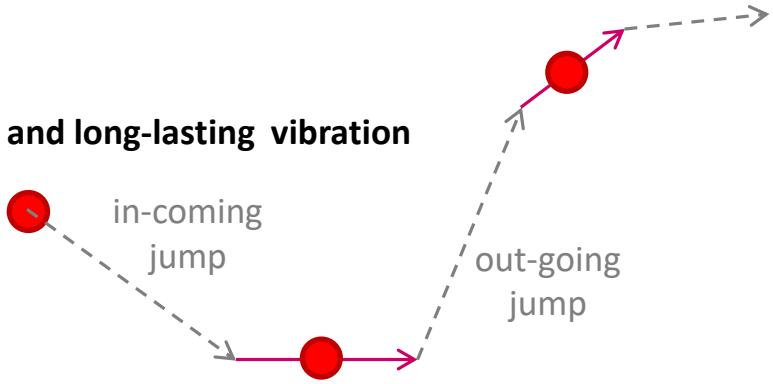
Required pos. accuracy: ± 1 µm ~ ± 2 µm (according to later communication with customer)
(for total system) ± 0.5 µm (according to the questionnaire filled in by customer)

⇦ **extreme challenge !!!**

Our recommendation: Jump-Mark-Jump Pattern (with **slsc_list_mark_abs**)
=> Viable solution because only **single shots** are fired
=> *Timing for firing the shot adjustable by **Q-Switch Delay** setting in Laser Mode 5 (a.k.a. 'YAG 5')
=> **Optimization by appropriate choice of **mark vector length, direction, and speed**

=> Advantage: Full stop never occurs
=> avoidance of large overshoot and long-lasting vibration

=> Achieved accuracy: ± 1 µm ~ ± 2 µm
in BOTH operation modes
A) XL *SCAN* mode with sync*AXIS*.dll
B) FLY mode with RTC6.dll + LCI



mark vector with optimized
length, direction, and speed

** : Refer to Min-Sang Lee's e-mail dated June 24., 2022*
*** : Refer to Min-Sang Lee's e-mail dated June 28., 2022*

Technical details, challenges, and trouble shooting

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=> Viable solution because only **single shots** are fired
=> *Timing for firing the shot adjustable by **Q-Switch Delay** setting in Laser Mode 5 (a.k.a. 'YAG 5')
=> **Optimization by appropriate choice of **mark vector length, direction, and speed**
=> **Further optimization possible via
slsc_list_set_calculation_dynamics_jump_scan_device + **FilterBandwidth** readjustment
slsc_list_set_calculation_dynamics_mark_scan_device + **FilterBandwidth** readjustment
slsc_cfg_select_heuristic + **DynamicReductionFunction** + **HeuristicForJumpsOnly** adjustment
=> ****Critical settings:**
LaserPreTriggerTime and **LaserSwitchOffsetTime**
DelayShift under **StageConfig**

=> Advantage: Full stop never occurs
=> avoidance of large overshoot and long-lasting vibration

=> Achieved accuracy: ± 1 µm ~ ± 2 µm
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A) XL *SCAN* mode with sync*AXIS*.dll
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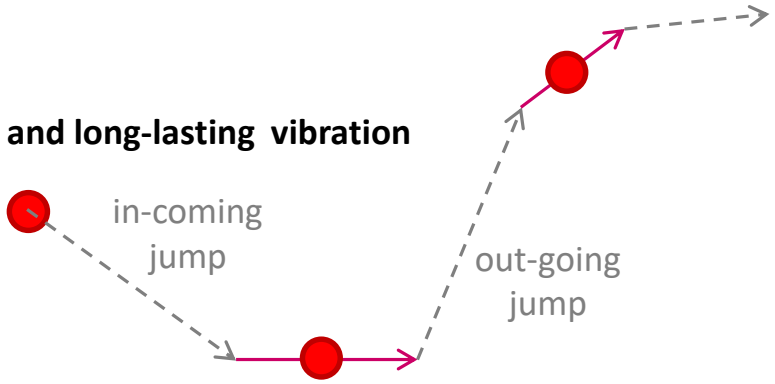

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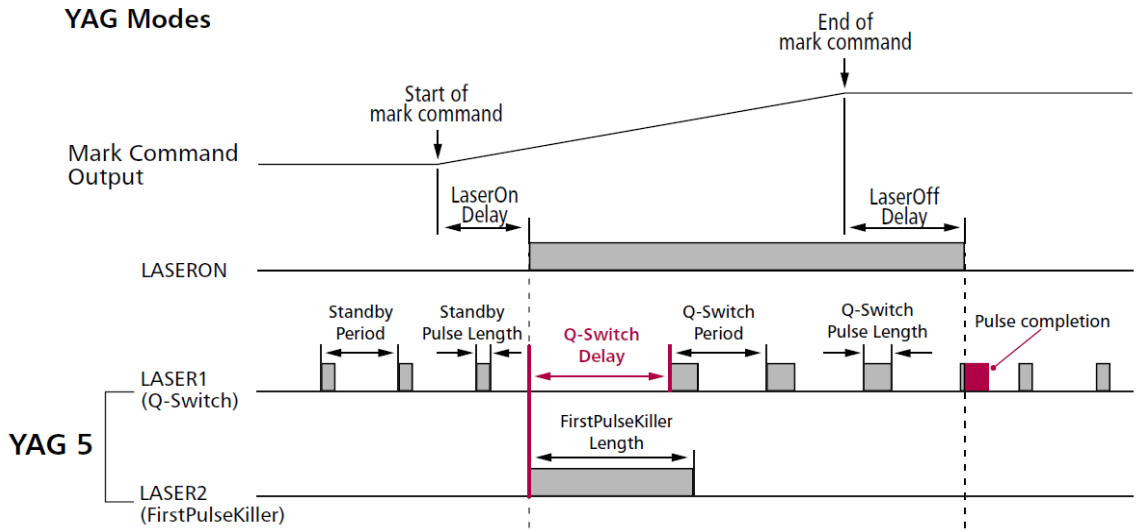
Technical details, challenges, and trouble shooting

Other types of encountered trouble: A) Misconfiguration in laser control setting
B) Mismatch between CTIME and DelayShift under StageConfig
C) Confusion of SLEC EtherCAT Node ID with SLEC Unit ID
D) Confusion about RTC6 options required for the use of XL *SCAN* / sync*AXIS*

A) Misconfiguration in laser control setting
Lumentum PicoBlade was supposed to be used according to the questionnaire filled in by the customer.

=> PicoBlade would have provided true Pulse-on-Demand (PoD) capability
meaning “LASER ON from RTC6 used as Ext. Gate” and “LASER 1 from RTC6 used as Ext. Pulse Trigger”
=> Laser Mode 5 (a.k.a. ‘YAG 5’) would have been the ideal setting allowing for max. degree of freedom.



excerpt from **RTC6 manual subsection 7.4.4**

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A) Misconfiguration in laser control setting
Lumentum PicoBlade was supposed to be used according to the questionnaire filled in by the customer.

=> PicoBlade would have provided the true Pulse-on-Demand (PoD) capability, meaning that, by using "LASER ON from RTC6" as Ext. Gate and "LASER 1 from RTC6" as Ext. Pulse Trigger, the timing of each laser pulse would have been controllable and determined by LASER ON and LASER 1 of RTC6.
=> Laser Mode 5 (a.k.a. 'YAG 5') would have been the ideal setting allowing for max. degree of freedom.

=> Later, however, we were told that Amplitude Satsuma was being used by the customer.
Although Amplitude Satsuma allows the user to choose between Ext. mode and Int. mode for Gate as well as between Ext. mode and Int. mode for Trigger, the operation with Gate => Ext. mode and Trigger => Ext. mode failed.

=> Symptom: **LaserSwitchOffsetTime** had to be set to **-1200 µsec.** or even further below to obtain acceptable results. However, due to the SW's internal constraints, it was not possible to go any further into more negative values than -1200 µsec.

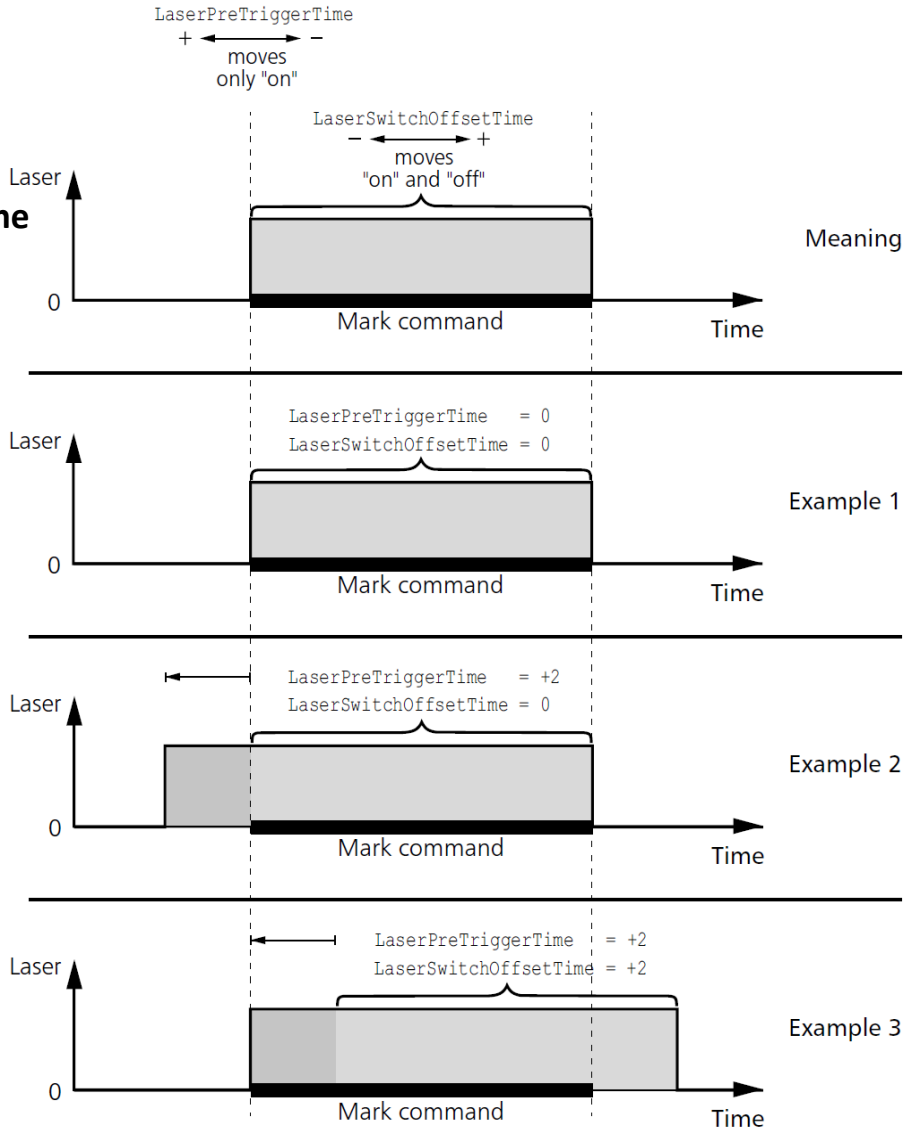
=> Solution: **Gate => Int. mode** and **Trigger => Ext. mode**
Laser pulse trigger worked at correct timing with this setting.

Technical details, challenges, and trouble shooting

Excursion:

Meaning of **LaserSwitchOffsetTime** and **LaserPreTriggerTime**

excerpt from **syncAXIS-DLL – API manual chapter 6** (under the description of **slsc_MarkConfig** structure)



Typ. range for LaserSwitchOffsetTime:
-40 µsec. ~ +10 µsec.

Typ. range for LaserPreTriggerTime:
-10 µsec. ~ +10 µsec.

Technical details, challenges, and trouble shooting

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B) Mismatch between **CTIME** and **DelayShift** under **StageConfig**

3.6 CTIME Value

The supported controller cycle times (CTIME) are:

- 0.20 msec
- 0.25 msec
- 0.50 msec

The CTIME value has an effect on the stage delay parameter.

Table 3-1. Stage delay paramter

CTIME	Delay parameter value
0.20	1.1881 [ms]
0.25	1.4881 [ms]
0.50	2.9382 [ms]

excerpt from ACS' Application Note "**ACS Components in XL *SCAN* System**"

In sync*AXIS* control ≤ V1.2.6, the positioning stage delay value needed to be entered based on the cycle time of the ACS protocol (ACS-Cycle Time, "**CTIME**") under <cfg:Configuration> → <cfg:**StageConfig**> → <cfg:**Delay** …> in the syncAXIS XML configuration file.

In sync*AXIS* control ≥ V1.3.0, however, this is not necessary anymore and the <cfg:Delay …> tag is not available either. Instead, by setting CTIME = -1, the user can let CTIME be automatically read out from the ACS Motion Controller and a corresponding positioning stage delay value is automatically set.

=> ACS' Application Note "**ACS Components in XL *SCAN* System**" will be updated.

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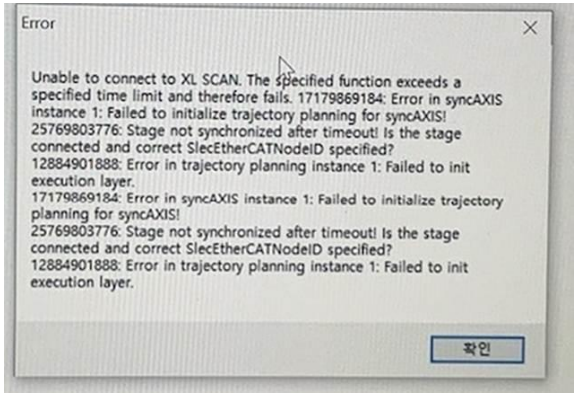
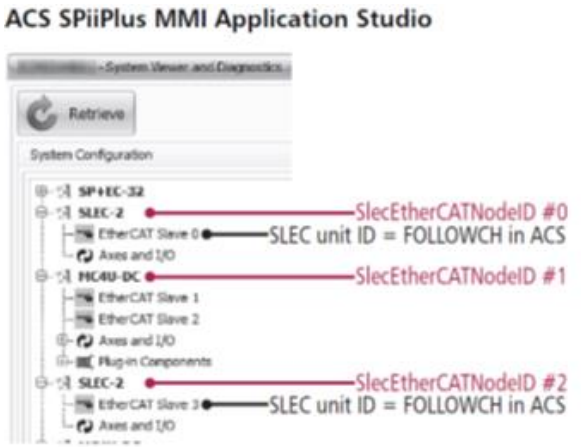


error encoutered by the customer while trying to initialize sync*AXIS*



excerpt from **syncAXIS installation manual section 6.1**

SlecEtherCATNodeID and Slec unit ID are not necessarily the same.
SlecEtherCATNodeID shall be specified by syncAXISConfig.xml in the correct sequential order in which the corresponding components are display by the System Configuration window of ACS SPiiPluss MMI Application Studio.
The Slec unit ID on the other hand is used in FOLLOWCH variable on ACS Motion Controller.

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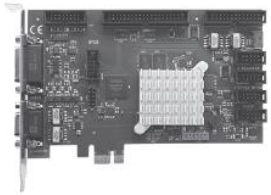
RTC6 PCI Express Board



RTC6 Ethernet Board
To date, only for 1-head setup

– with option "syncA" and option "SCANa"

⇦ excerpt from **syncAXIS installation manual section 2.3**

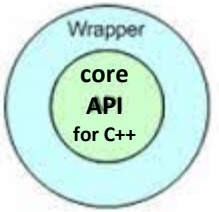
NOTE: The only required RTC6 options are sync*AXIS* option "**syncA**" and *SCAN*ahead option "**SCANa**".
Neither FLY option nor SSHC (Secondary Scan Head Control) option is required for the use of XL *SCAN* / sync*AXIS*.
Unlike other options, "**syncA**" does not incur any surcharge.
If any of the required options is missing, the respective RTC6 board can be remotely upgraded by a ZIP file provided by SCANLAB. For this purchase, SCANLAB needs to be notified of the serial number of the RTC6 board.

Technical details, challenges, and trouble shooting

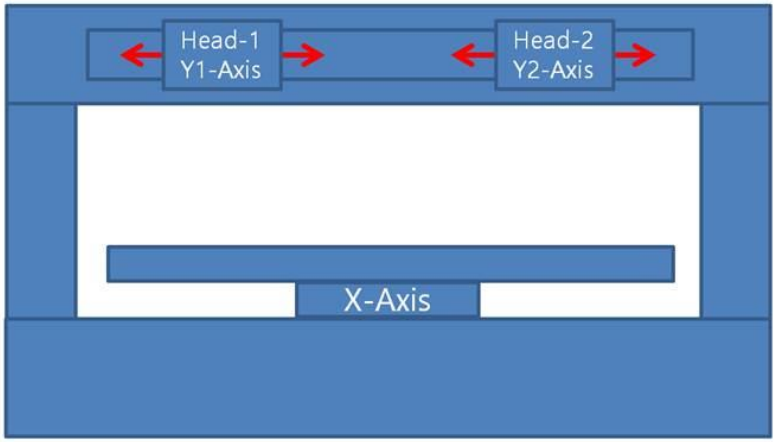
Other peculiarities:
no trouble, but subject to clarification

1) Request for C# API (instead of the standard C++ API) and example code
2) Dual-head setup without synchronization between the heads
3) Request for a function to change the FilterBandwidth parameter

1) Request for C# API (instead of the standard C++ API) and example code
   => SCANLAB offers the interface for C# programmer only in the form of a wrapper.
   => The wrapper and example code haven been sent to the customer via PRESTO.



2) Dual-head setup without synchronization between the heads



Customer's statements:
The two scan heads shall be operated

i) in different motion patterns
ii) not synchronously nor simultaneously, but one after another

⇒ Conclusion: both multi-head version and multi-instance version of syncAXIS not suitable nor necessary
⇒ Just a single-instance, single-head version of syncAXIS can be used by alternating between two XML files for #A(eS14+RTC6+SLEC) and #B(eS14+RTC6+SLEC).

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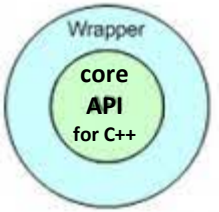

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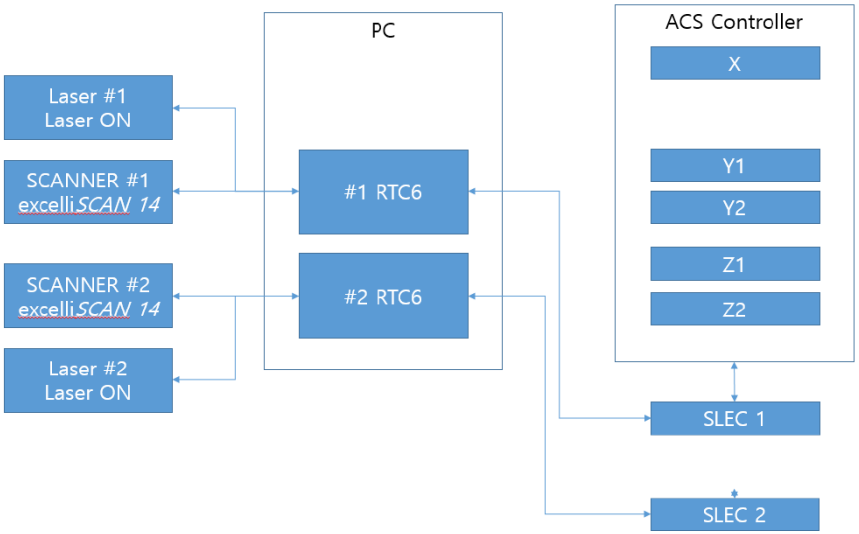

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=> The sync*AXIS* configuration function **slsc_cfg_set_bandwidth** is available and allows the user to change FilterBandwidth outside of the XML configuration file, in order to adjust the motion portions distributed and each of them assigned to scanner and to stage (in other words, to vary the utilized area within the scanner's FoV).

Side Remark:
The customer's stage exhibited impressively high dynamic performance, as the customer encountered no even at a very large **FilterBandwidth** of 20 Hz.

On-site & remote support

On-site & remote support

To summarize:

All in all, not much actual work was done during the session on June. 27 (Mon.), 2022.

- Customer showed how the position errors were measured (using camera vision) and these errors were influenced by differing settings of laser delays.

- Then we went through the steps of optimization and verification process described in the sync*AXIS* installation manual sections 7.1 – 7.5 and discussed other possible measures to be taken for further improvement of accuracy.

- The actual improvement of accuracy was achieved later by switching from Jump-Stop-Shoot pattern to Jump-Mark-Jump pattern in accordance with SCANLAB's recommendation. However, the actual implementation entailed a lot of trials and errors for optimization.

- The positive outcome is owed to the customer's determination and commitment to bring the project to a successful closure. Also, the process and equipment engineers on the customer side showed high degree of capability to gain good understanding of how XL *SCAN* / sync*AXIS* works and accumulate the knowhow in operating and optimizing the XL *SCAN* setup within very short period of time, which obviously contributed a lot to the success.

Customer's complaints

=

Our potential for improvement

Customer's complaints / our potential for improvement

- Manuals difficult to read and understand; missing example codes and application notes

- Answers to questions not immediate (e.g., about RTC6 options, multi-head or multi-instance versions of syncAXIS etc.)

- Missing 24h/7d on-call duty for support (in particular SW support)

- Presence of supporting parties not complete during on-site & remote support session

Customer's complaints / our potential for improvement

- Manuals difficult to read and understand; missing example codes and application notes
  => to be tackled by SCANLAB's application engineering and documentation division

- Answers to questions not immediate (e.g., about RTC6 options, multi-head or multi-instance versions of syncAXIS etc.)
  => to be tackled by info materials and training from SCANLAB provided to ShinHoTek and PRESTO as well as by ShinHoTek's and PRESTO's studies using the info materials

- Missing 24h/7d on-call duty for support (in particular SW support)
  => to be tackled by info materials and training from SCANLAB provided to ShinHoTek and PRESTO as well as by ShinHoTek's and PRESTO's studies using the info materials

- Presence of supporting parties not complete during on-site & remote support session
  => to be tackled by pro-active engagement in support activities and improved communication + coordination among ShinHoTek, PRESTO, and SCANLAB