Master/Slave Guiding Systems

Documentation

Master/Slave guiding (also known as Leader/Follower or Coordinated Control) is essential for lamination and multi-layer processes where a "Slave" web must align perfectly with a moving "Master" web, rather than a stationary machine frame. While legacy systems rely on complex motorized mechanical linkages to physically move sensors, Roll-2-Roll Technologies achieves this through **Instantaneous Electronic Guide Point Adjustment**. By connecting both the Master and Slave sensors to a single Roll-2-Roll® Controller, we electronically guide the Slave web to the Master web position. This eliminates mechanical backlash, allows for multi-slave synchronization, and enables advanced capabilities like centerline matching without moving parts—reducing setup time and ensuring high-precision alignment for lamination and multi-web converting.

The Challenge: The Complexity of "Mechanical Chasing"

In lamination processes, the Master web often wanders. To ensure the Slave web aligns with it, legacy systems use a method called **Mechanical Chasing**.

- **The "Linked Sensor" Mechanism:** In legacy systems, the Master sensor is mounted on a motorized slide that physically moves to chase the Master web's position. The Slave sensor is mechanically synchronized to this mechanism. When the Master sensor moves, the Slave sensor moves the exact same distance, forcing the Slave guide to reposition the web.
- **Tuning Nightmares:** This approach creates a "loop within a loop." You have the control loop for the web guide and a separate control loop for the motorized sensor slides. These multiple loops often fight each other, leading to instability and difficult tuning issues.
- **Mechanical Failure Points:** These systems rely on lead screws, motors, and sliding brackets that are in constant motion. This results in significant wear, backlash, and maintenance downtime.
- **Constant Offset Adjustments:** With legacy narrow-beam sensors, when the master or slave web width changes, operators must manually recalculate and adjust the guide point offset. This wastes time and introduces errors.

The Solution: Roll-2-Roll Technologies Electronic Synchronization

We replaced mechanical linkages with digital intelligence. By connecting both the Master and Slave sensors to a **single** **Roll-2-Roll® Controller**, we eliminate the need for the Slave sensor to physically move.

How Electronic Chasing Works

Instead of moving the sensor, we move the **Guide Point** (the reference position).

1. **Dual Input, Single Brain:** The Master Sensor and Slave Sensor both feed into one SCU5 or SCU6x controller. Both controller families support two independent sensor channels.
2. **Feed-Forward Signaling:** The controller detects the exact position of the Master web. It treats this position as a dynamic "Guide Point" for the Slave loop.
3. **Instantaneous Adjustment:** As the Master web wanders, the controller electronically shifts the guide point for the Slave web guide in real-time. The Slave web follows the Master web immediately, without the lag caused by mechanical sensor positioners.
4. **Simple Lamination Offsets:** Need the top layer to be offset by exactly 5mm for an adhesive reveal? You can program a digital offset in the controller without moving any hardware.

The Wide Sensor Advantage: Centerline Matching

A unique advantage of Roll-2-Roll® Sensors is the ability to perform **Master/Slave Center Guiding** —something legacy systems simply cannot do.

- **The Concept:** Wide field-of-view sensors (ODC 480, ODC 768, or ODC 960) can see **both edges** of the web simultaneously.
- **The Execution:** The controller calculates the *Centerline* of the Master web and the *Centerline* of the Slave web. It then guides the Slave web so that its center aligns perfectly with the Master's center.
- **Different Widths, No Problem:** Even if the master web is 400mm wide and the slave web is 350mm wide, the controller automatically aligns their centerlines. **No manual offset adjustments needed when web width changes.**
- **Time Saved:** Operators no longer need to recalculate and enter new offset values every time they change web widths—a tremendous time saver that eliminates a major source of errors.

Feature	Mechanical Chasing (Legacy)	Electronic Master/Slave (Roll-2-Roll Technologies)
Mechanism	Motorized Sensor Positioners	**Software (Feed-Forward Signal)**
Wear Parts	Motors, Gears, Lead Screws	**None (Solid State)**
Synchronization	Difficult (Mechanical Lag)	**Instant (Electronic)**
Width Changes	Manual offset recalculation	**Automatic (Centerline matching)**
Multi-Slave Scaling	Complex mechanical linkages	**Ethernet broadcast to multiple controllers**
Cost	High (Extra actuators required)	**Low (Standard hardware)**

Real-World Application: 14-Lane Cascading Alignment

One Roll-2-Roll Technologies customer operates a multi-lane converting line with **14 separate web lanes** from multiple unwinds. The requirement: align all lanes edge-to-edge with no overlap or gaps.

The Configuration

- **Each lane has two sensors:** One sensor monitors the "master" edge (the edge that the previous lane aligned to), and the other sensor guides the web via a slave guide.
- **Cascading logic:** Lane 1's right edge position sets the guide point for Lane 2's slave guide. Lane 2's right edge then sets the guide point for Lane 3, and so on through all 14 lanes.
- **Result:** All 14 webs automatically maintain edge-to-edge alignment. If one lane's web is wider or shifts, all subsequent lanes adjust accordingly.

Future Enhancement: Central PLC Integration

In the cascading configuration, changes propagate lane-by-lane. For even faster response, the SCU6x controller's industrial Ethernet connectivity (EtherNet/IP, PROFINET, EtherCAT, Modbus/TCP) enables a **central PLC architecture** where any lane change can instantly adjust the guide points for all subsequent lanes simultaneously.

Engineering Guide: Critical Installation Rules

Implementing Master/Slave guiding requires specific attention to web path geometry to ensure the Slave web reacts at the exact moment the Master web error arrives.

Matching Web Path Lengths

For the Slave web to react to a Master web error at the exact right moment, the distance the web travels must be synchronized.

- **The Rule:** The web path distance from the **Master Sensor to the Lamination Nip** should be equal to the web path distance from the **Slave Sensor to the Lamination Nip**.
- **Why?** If the paths are unequal, the Slave guide might correct for an error before that error actually reaches the lamination point (phase mismatch).
- **The Fix:** If physical constraints prevent matching path lengths, Roll-2-Roll® Controllers can apply **dynamic compensation** to the feed-forward signal, electronically delaying the correction to match the transport time.

Sensor Field of View

Because the sensors are fixed (not chasing), they must have a field of view wide enough to see the web at its maximum wander.

- **For edge-to-edge guiding:** Sensor range must cover the total expected wander of the Master web plus the Slave guiding range.
- **For centerline matching:** Use wide sensors (ODC 480 or larger) that can see both edges of both webs simultaneously.

System Configurations (Select Your Kit)

Standard Master/Slave Kit

Best for: Adhesive lamination, masking, and multi-layer converting.

- **Master Loop:** 1× ODC 192 or ODC 288 sensor (monitors Master web position)
- **Slave Loop:** 1× Roll-2-Roll® Web Guide (actuator + mechanism) + 1× ODC 192 or ODC 288 sensor
- **Controller:** 1× SCU6x (handles both sensor inputs and coordinates the locking logic)

Centerline Matching Kit

Best for: Different web widths, frequent width changes, center-to-center alignment.

- **Wide Sensors:** 2× ODC 480, ODC 768, or ODC 960 (must see both edges of each web)
- **Controller:** 1× SCU6x with centerline calculation enabled
- **Benefit:** Automatic alignment regardless of width differences—no offset adjustments

Multi-Web Synchronization Kit

Best for: Battery manufacturing (anode/cathode stacking), multi-ply tissue, 3+ layer lamination.

- **Concept:** One Master web acts as the reference. Multiple Slave webs must align to it.
- **Execution:** The Master sensor signal is broadcast to multiple Slave controllers via industrial Ethernet (EtherNet/IP, PROFINET, EtherCAT, or Modbus/TCP). This ensures 3, 4, or more layers all lock to a single master reference without complex mechanical linkages.

Technical Specifications

Roll-2-Roll® Controllers support Master/Slave logic out of the box.

Parameter	Specification	Note
Coordination Type	Electronic Feed-Forward	Eliminates mechanical lag
Sensor Inputs per Controller	2 independent channels	Both SCU5 and SCU6x
Sensor Resolution (48-288mm)	0.0635 mm (0.0025 in)	Hardware resolution
Sensor Resolution (384-960mm)	0.127 mm (0.005 in)	Wide sensors for centerline
Repeatability	>99.9%	Verified specification
Offset Capability	Digital (± mm)	Adjustable via touchscreen or Ethernet
Update Rate	50 Hz	Real-time synchronization
Industrial Protocols	EtherNet/IP, PROFINET, EtherCAT, Modbus/TCP	For multi-slave and PLC integration
Max Slaves	Scalable	One Master can drive multiple Slaves

Cost of Inaction: What Legacy Systems Are Costing You

Every week you operate with mechanical master/slave systems, you're accumulating losses across all four cost pillars:

Direct Costs (Visible on P&L)

- **Misalignment scrap:** Layer registration errors lead to rejected product—especially costly in battery electrode stacking where misalignment causes safety failures
- **Material waste:** Running wider margins to compensate for alignment uncertainty wastes expensive substrates
- **Rework costs:** Delamination and adhesive misregistration require re-running jobs

Hidden Costs (Buried in Overhead)

- **Offset adjustment time:** Every width change requires manual offset recalculation and entry—legacy systems demand this, centerline matching eliminates it

- **Mechanical positioner maintenance:** Lead screws, motors, and sliding brackets in constant motion wear out, requiring parts and labor
- **Tuning time:** "Loop within a loop" instability means hours spent tuning competing control loops instead of running production
- **Troubleshooting:** When mechanical and electronic systems fight each other, diagnosing the root cause consumes engineering time

Risk Costs (Probability × Severity)

- **Quality escapes:** Misaligned laminations that reach customers result in returns, credits, and damaged relationships
- **Battery safety:** In Li-ion manufacturing, electrode misalignment can cause lithium plating and thermal runaway—a catastrophic safety risk
- **Customer audits:** Legacy mechanical systems lack the data logging and repeatability documentation modern customers require

Opportunity Costs (Value Left on the Table)

- **Width flexibility:** Without centerline matching, you're limited to running master/slave webs of similar width—or spending time on manual adjustments
- **Multi-lane scaling:** Adding lanes to a mechanical system requires exponentially more complexity; electronic synchronization scales linearly
- **Speed limitations:** Mechanical lag forces slower line speeds to maintain alignment accuracy
- **Changeover delays:** Time spent adjusting offsets and retuning is time not spent producing product

The bottom line: The capital cost of eliminating mechanical positioners is typically recovered within 12 months through maintenance savings alone—before counting the productivity gains from centerline matching and faster changeovers.
