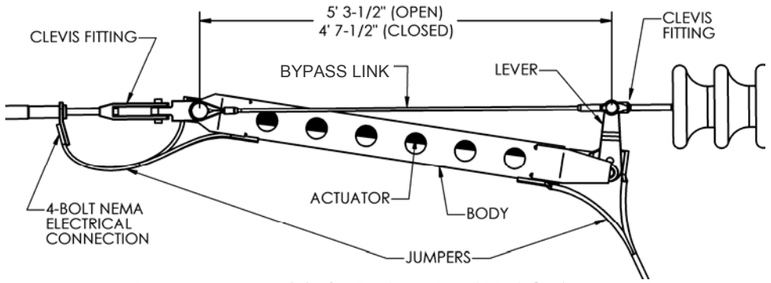
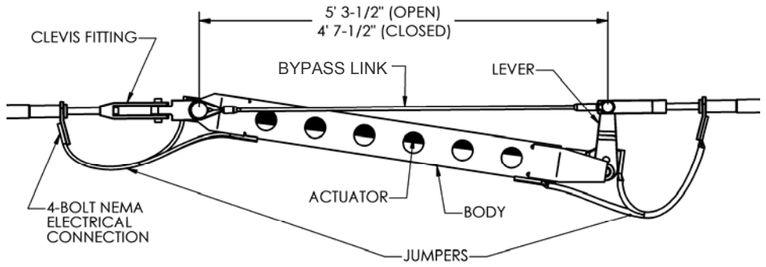


Major components of the SLiM device (Dead-End Configuration).



Major components of the SLiM device (In-Line Configuration).

Table 1: Operating Parameters for Standard* SLiM

Criteria	Application
Voltage Rating	230kV and below. Higher voltages (345 & 400kV) possible.
Target Conductor	Conductors with a breaking load ≤ 40,000 lb (180 kN)
Range of Motion	Up to 8" (200 mm)
Line Tension @ 110°F	Up to 5,000 lbs. (22.5 kN)
Functional Temperatures	~120–212°F (50-100°C) (conductor temperature)
Mechanical Failure Load	> 49,000 lbs. (218 kN) – Tested per IEC at Kinectrics
Electrical Current Capacity	> 1400 A
Short Current Rating	40 kA (rms) – Tested per IEC at Kinectrics
Total Weight	~ 85 lbs. (380 N) (Production Version)
End-to-end Dimension	~ 5' 3½" (1610 mm) open, 4' 7½" (1410 mm) closed
End Connectors	Any standard connector with 1" clevis pin (Utility's choice)
Installation	"Cold" using standard procedures – or – "Live" using live-line hand procedure (similar to splicing procedure). Detail procedure available upon request.

* Custom sizes for special applications available.

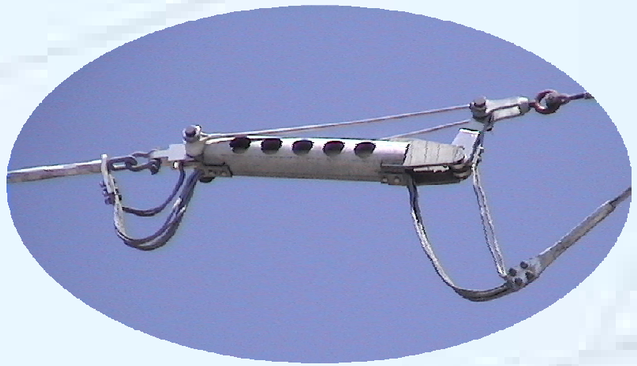
Table 2: Example Sag Mitigation for Drake Conductor

Span	Conductor Temperature*		Excess Sag due to Heating		Sag
	Initial	Final	Without SLiM	With SLiM	Reduction
ft / m	°F / °C	°F / °C	ft / cm	ft / cm	ft / cm
750 / 230	110 / 43	212 / 100	5.2 / 158	0.2 / 6	5.0 / 152
1000/300	110 / 43	212 / 100	6.0 / 183	1.9 / 58	4.1 / 125

* Tension at 40°F considered equal to 20% of tensile strength of conductor.

SLiM

Sagging Line Mitigator



- ***SLiM solves sag problems rather than just monitoring them***
- ***SLiM allows for increased power flow and avoids clearance issues***
- ***SLiM is maintenance free***
- ***SLiM is fail-safe and practically indestructible***
- ***SLiM is beyond R&D and is being used as a product!***

The Sagging Line Mitigator (**SLiM**) is a new class of transmission line hardware that fixes the sagging problem of transmission lines at just the right time. By using state-of-the-art materials and a proven and patented concept, SLiM reacts to increasing conductor temperature by decreasing the effective length of conductor in the span. The impact is a decrease in line sag during the high temperature and/or high loading conditions.

SLiM was originally developed by Material Integrity Solution, Inc. (MIS), of Berkeley, CA with funding from California Energy Commission. It has been extensively studied and tested by MIS, Pacific Gas and Electric Company, Hydro Quebec Institute of Research (IREQ) and Kinectrics. SLiM was installed and tested at San Diego Gas and Electric as part of a Tailored Collaboration demonstration project with the Electric Power Research Institute (EPRI) on behalf of San Diego Gas and Electric, Pacific Gas and Electric, Southern California Edison, Public Service of New Mexico, Consolidated Edison, British Columbia Hydro, National Grid Transco (UK), Northeast Utilities, and the California Energy Commission. SLiM has been installed and is being monitored on a 220kV line in Sichuan Electric Power Company, China, since 2007. Also ESKOM has been extensively evaluating the device in both laboratory and field conditions.

SLiM is being produced by Power Transmission Solutions, Inc. (PTS). To order the device, to determine how SLiM device can solve your specific sag problem, to design optimum SLiM location(s) for your specific situation, or, just for more information please contact us.

Power Transmission Solutions, Inc.
3254 Adeline St., Suite #205
Berkeley, CA 94703 USA
+1 (510) 410-4046
info@PTranSolutions.com
www.PTranSolutions.com

SLiM Specifics

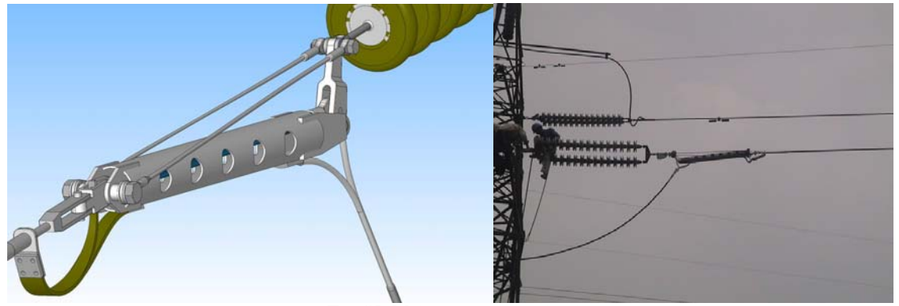
General
SLiM mitigates excessive sag in transmission system by reducing the effective length of the conductor. This is achieved by using a design that amplifies and transfers the movement of a shape-memory alloy actuator to the line. The SLiM device is made of high quality and strong materials for high strength, excellent corrosion resistance, and long life. It is constructed using special techniques including precision casting, forging, and machining; and is assembled by experienced technicians. Each device is fully tested prior to shipping.

Electrical Connection
The SLiM device carries the full line current, splitting the current between the actuator and the body of the device. Standard flexible connectors carry current between the transmission line and the SLiM device. The electrical connectors on the device terminate with 4-bolt NEMA paddles for easy connection to standard line hardware.

Mechanical Connection
The SLiM device is installed in series with the transmission line. Either end of the device is equipped with standard oval-eye end fittings. The mating attachment on the conductor is the ***choice of the utility***. The device accepts any industry standard dead-end attachment with a 1" clevis pin. Options include dead-end compression fittings, preformed dead ends, and wedge dead ends.

Installation
The device can be installed at a deadend, or anywhere along a span using live-line procedures similar to line splicing techniques. During installation, a piece of conductor approximately the length of the SLiM device is removed and replaced by the device. The length of conductor to be removed as well as the number and locations of devices along a section of transmission line can be determined using line sagging software for optimum performance. PTS is available to provide engineering support to help determine the optimum installation practice.

"Installation of SLiM device was very straightforward," said linemen who installed SLiM.



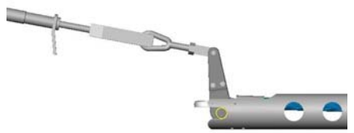
The SLiM device at a deadend

Some Applications of SLiM

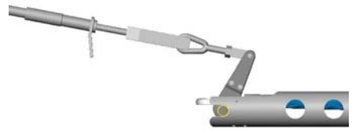
- A system contingency situation can cause loading on nearby transmission lines exceeding their thermal limits. These limits are normally established to maintain conductor line-to-ground clearances. Thus, the action of SLiM, which mitigates the excess sag caused by high temperature operation, can allow for safe line operation during these contingencies. Line capacity is increased by allowing operation beyond conventional thermal limits, and expensive line modification projects may not be required.
- Many older lines were constructed to 120°F maximum conductor temperature operation. Studies have shown that SLiM can enable operation of such lines at a conductor temperature of about 200°F without compromise of line clearances or tensions. This can represent a multi-fold increase of rated line capacity.
- System planning may project that certain lines will become overloaded as local growth increases demand. In this instance SLiM can delay the need for either a new line or considerable line modifications while the anticipated load materializes.
- Line routing or line modifications near airports quite often require structures to be as low-profile as possible. SLiM can be employed in a cost effective fashion to minimize tower height for such installations while maintaining required ground clearances.
- Limitations on line ampacity due to a road or river crossing can be lifted by using SLiM device.
- … *many more* …

How SLiM Works

SLiM is activated by the same temperature changes that cause a conductor to sag too much. The device is passive – there are no motors or electronic controls. As high temperature increases conductor length and hence its sag, SLiM changes its geometry to decrease line length. As conductor temperature returns to normal, SLiM returns to its original shape. It is always ready to respond to the next conductor temperature excursion. And, the conductor always remains within acceptable sag and tension limits.

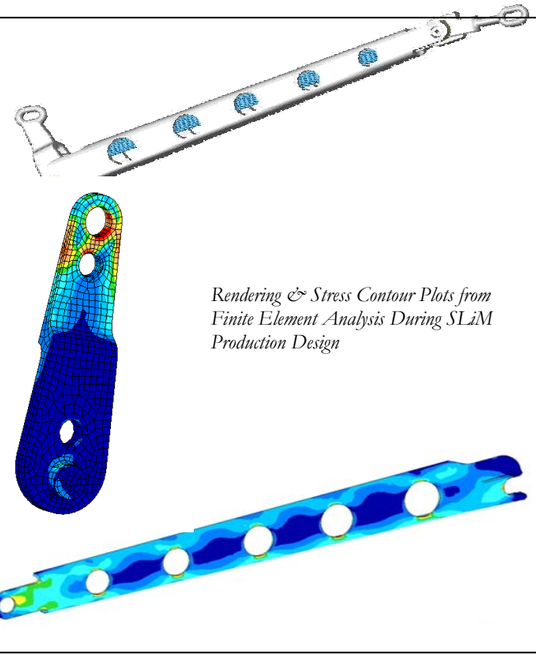


SLiM Normal Position



SLiM In Operation

SLiM is rugged, strong, maintenance-free, and designed to have a very long life. It is composed primarily of high quality metals and is designed for easy installation by linemen using live-line procedures. Industry standard connectors attach SLiM to the line. Its operation is adjustable to match specific line and configuration requirements. SLiM has no negative effects on line electrical performance.



Rendering & Stress Contour Plots from Finite Element Analysis During SLiM Production Design

Alternatives to Using SLiM

Conventional solutions to the problem presented by line operation conditions that cause high conductor temperature operation:

1. Replace the existing conductor with a premium conductor that can operate at high temperatures without increased sag.
2. Reinforce line structures and foundations for increased mechanical loading and either reconductor with a larger conductor or bundle with the existing size conductor.
3. Raise towers at key line locations to provide for increased ground clearance (may require foundation reinforcement).
4. Add intermediate towers at key line locations to increase ground clearances.
5. Install a line sag monitoring system and the infrastructure to absorb this information and require operators to curtail load when sags are too great.

These alternatives are all more costly and/or less reliable solutions than SLiM!

Acknowledgement

Development, testing and demonstration of SLiM was made possible by contributions from California Energy Commission – PIER program, Electric Power Research Institute, and Material Integrity Solutions, Inc.

California Energy Commission pier

Material Integrity Solutions, Inc.
www.MISolution.com