



**LILIKOI** innovation  
PATENT PENDING FORCE FEEDBACK TECHNOLOGY

**micronor  
sensors**

Booth 615

# Force Sensor



**FEMTO Gripper, Grasper, Inline and Smart Bracket  
Force Sensors will transform robotics and automation  
in harsh environments**

Presented by Dennis Horwitz, President, Micronor Sensors

Sensors Converge LIVE Theater  
Wednesday, June 26 2024

# Why Fiber Optics?



Immune to  
Electrical and RF Fields



Immune to Lightning  
and High Voltage



Radiation Resistant



Extremely  
Small Size



Transparent to  
Magnetic Fields



Wide Temperature Range



Inherently Safe



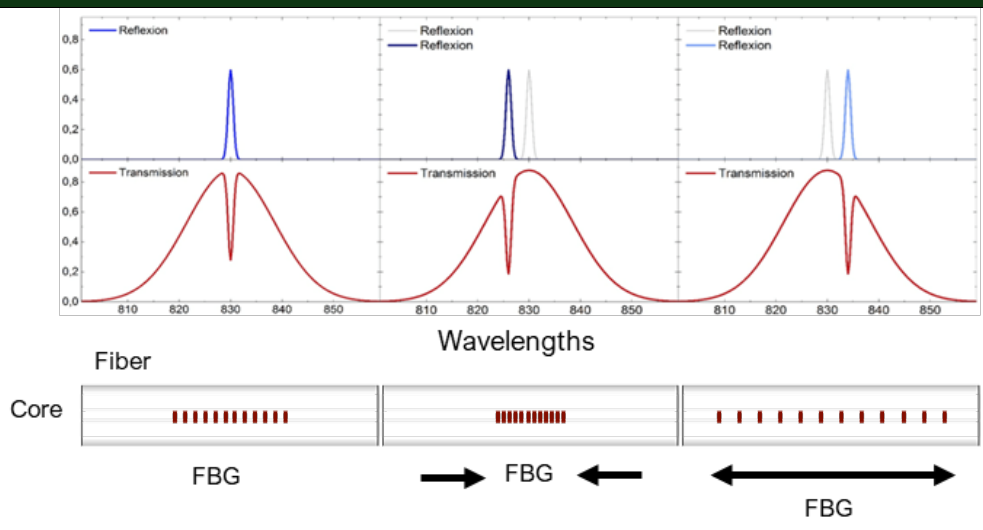
Interference-Free  
Over  
Long  
Distances

# Multipoint Temperature & Strain Sensing with Fiber Bragg Gratings (FBG)

FiSens® FBG System: Interrogator + Fiber Sensor Chain



## Principles of Operation



The Bragg wavelength is sensitive to both strain and temperature. The relative shift in the Bragg wavelength  $\Delta\lambda_B/\lambda_B$ , is due to applied strain  $\epsilon$  and change in temperature  $\Delta T$ :

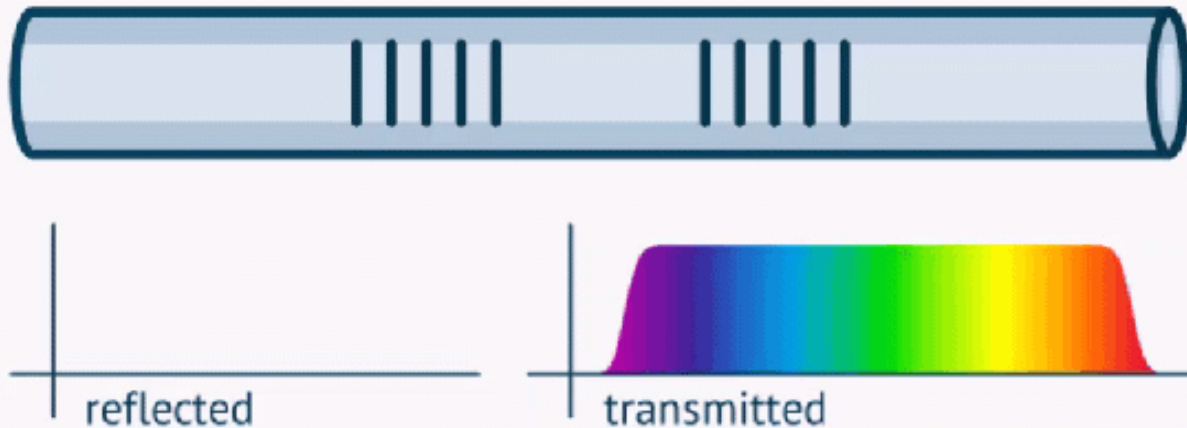
$$\left[ \frac{\Delta\lambda_B}{\lambda_B} \right] = C_S \epsilon + C_T \Delta T$$

where:

$C_S$  is the coefficient of strain

$C_T$  is the coefficient of temperature

# Single and Multipoint Sensing - FBGs



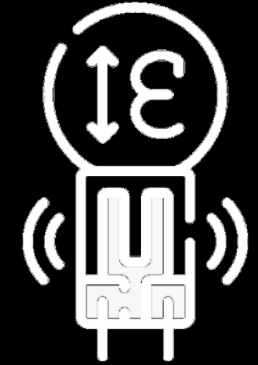
Reflected wavelength of a particular FBG is a function of both temperature and strain on that FBG.

FiSpec FBGs and interrogators operate in the 850nm window, the fundamental Bragg Wavelength of each FBG corresponds to 21°C and 0  $\mu\epsilon$  ( $\mu\text{m}/\text{m}$ ).

$$\left[ \frac{\Delta\lambda_B}{\lambda_B} \right] = C_S \epsilon + C_T \Delta T$$

# Strain Gauges are the GO-TO force sensor...

Cost-effective, reliable, durable,  
versatile, and easy to install.



**However, they are susceptible to errors and interferences:**

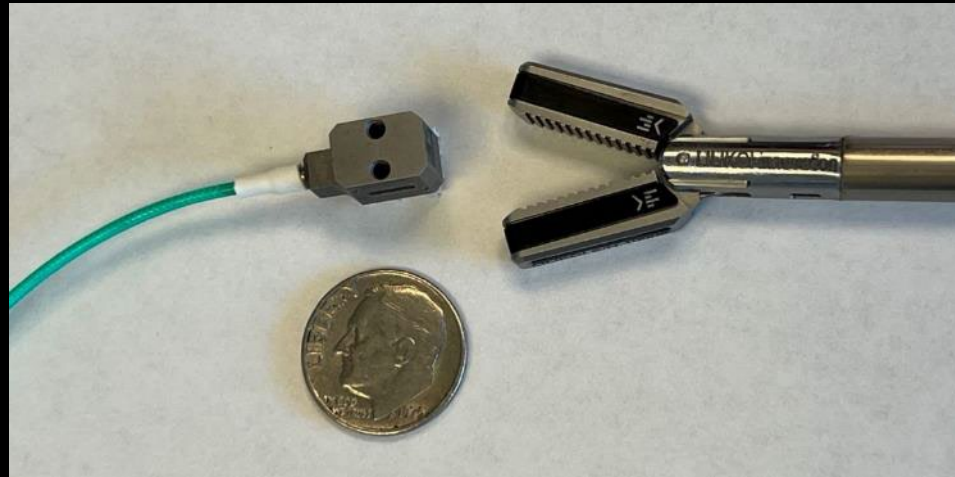
- Changes in resistance due to temperature and humidity,
- Hysteresis, creep or fatigue that reduce accuracy and repeatability,
- Require calibration, compensation or correction for different loading conditions.

**Innovations in Fiber Bragg Grating interrogators by Fisens has reduced the size and cost of the FBG interrogator, enabling embedded FBG applications...**



distributed by  
**micronor  
sensors**

**...and the development of femto (very very small)  
FBG-based Force Sensors by Lilikoi Innovation  
provide the size, cost and performance to enable  
new miniature medical robotics and other harsh  
environment automation.**





**LILIKOI** innovation

PATENT PENDING FORCE FEEDBACK TECHNOLOGY

FG25



GS05

GR25



GR10



**IMMUNITY SERIES  
OPTICAL FORCE SENSORS**  
*Based on FBG Technology*

- *EMI and High Temperature Immunity*
- *Temperature compensation*
- *High accuracy force measurement*
- *Operating Temp -55 °C to +200 °C*
- *Femto miniature packaging*



**STRAIN GAUGE SERIES  
FORCE SENSORS**

- *Reliable and accurate*
- *Low cost*
- *Femto miniature packaging*



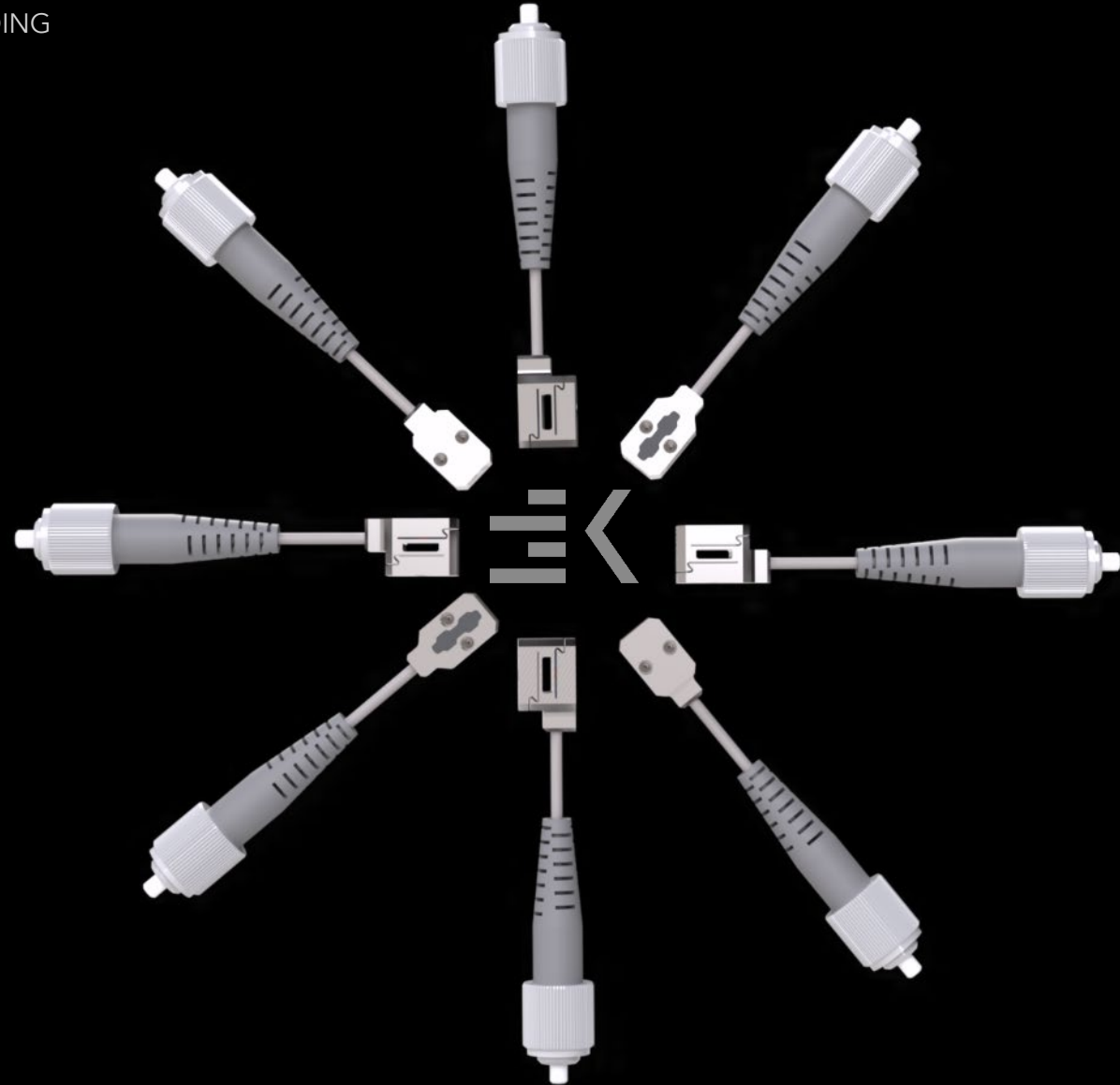
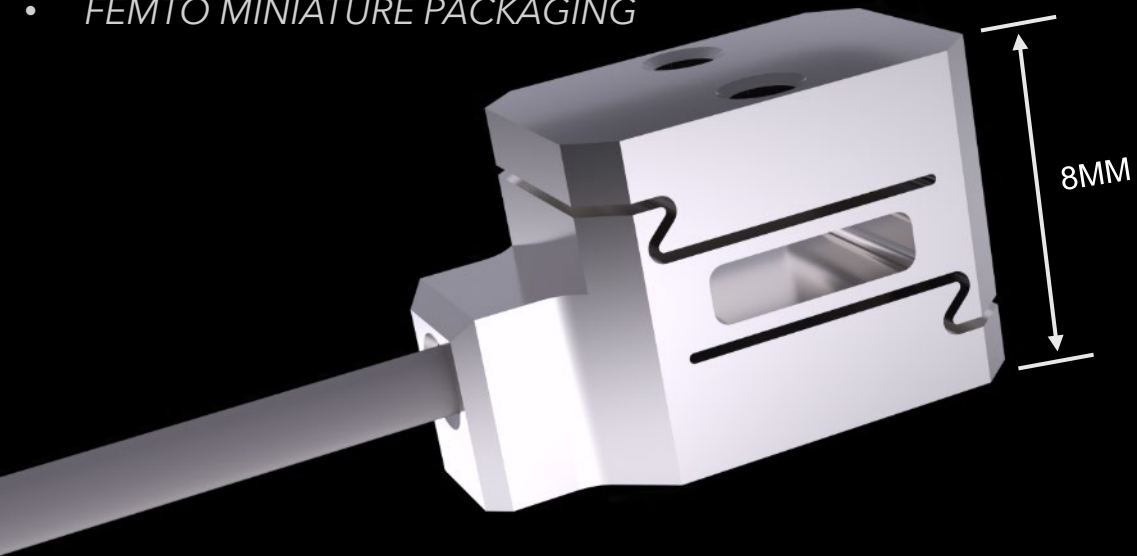
# FG25 FEMTO FBG IN-LINE FORCE SENSOR

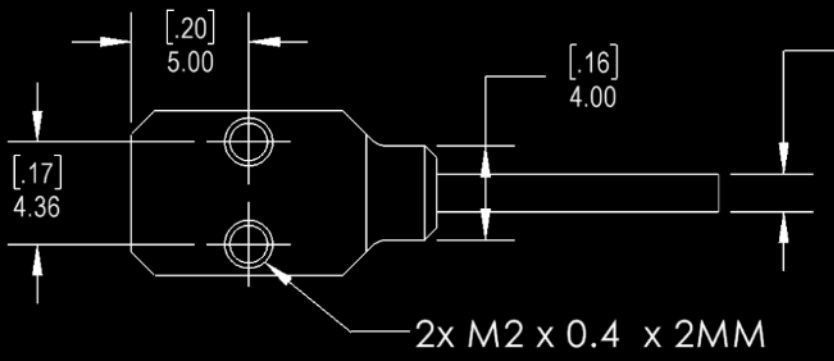
PATENT PENDING



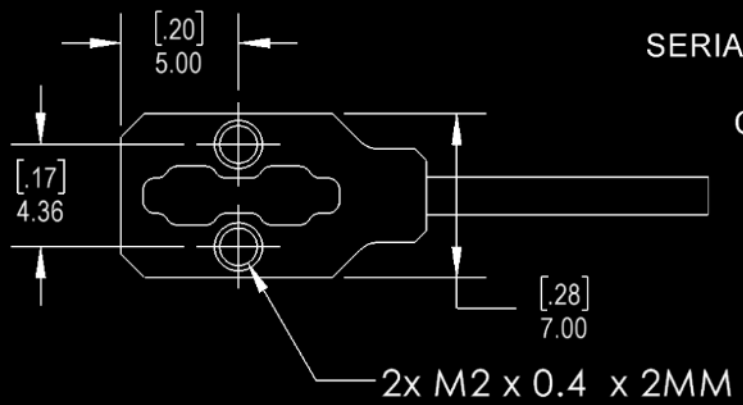
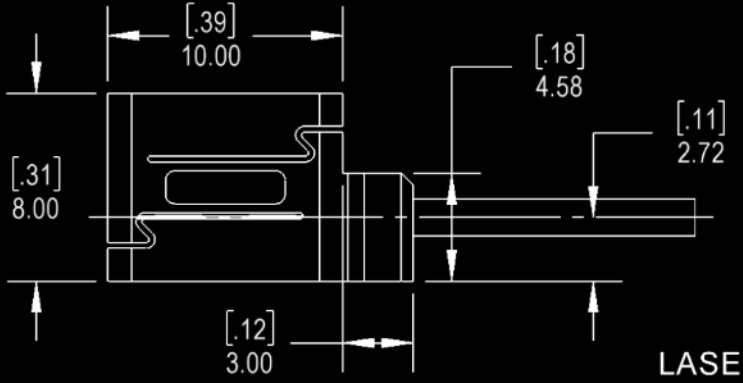
## IMMUNITY SERIES:

- EMI & HIGH TEMPERATURE IMMUNITY
- TEMPERATURE COMPENSATION
- HIGH ACCURACY FORCE MEASUREMENT
- FEMTO MINIATURE PACKAGING





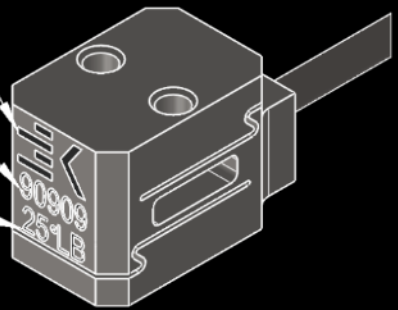
[.06]  $\varnothing$  1.60  
JACKET OD NOM



LASER MARKING:  
LILIKOI LOGO

SERIAL NUMBER

CAPACITY



# IMMUNITY SERIES FG25 FEMTO OPTICAL FORCE SENSOR

PATENT PENDING

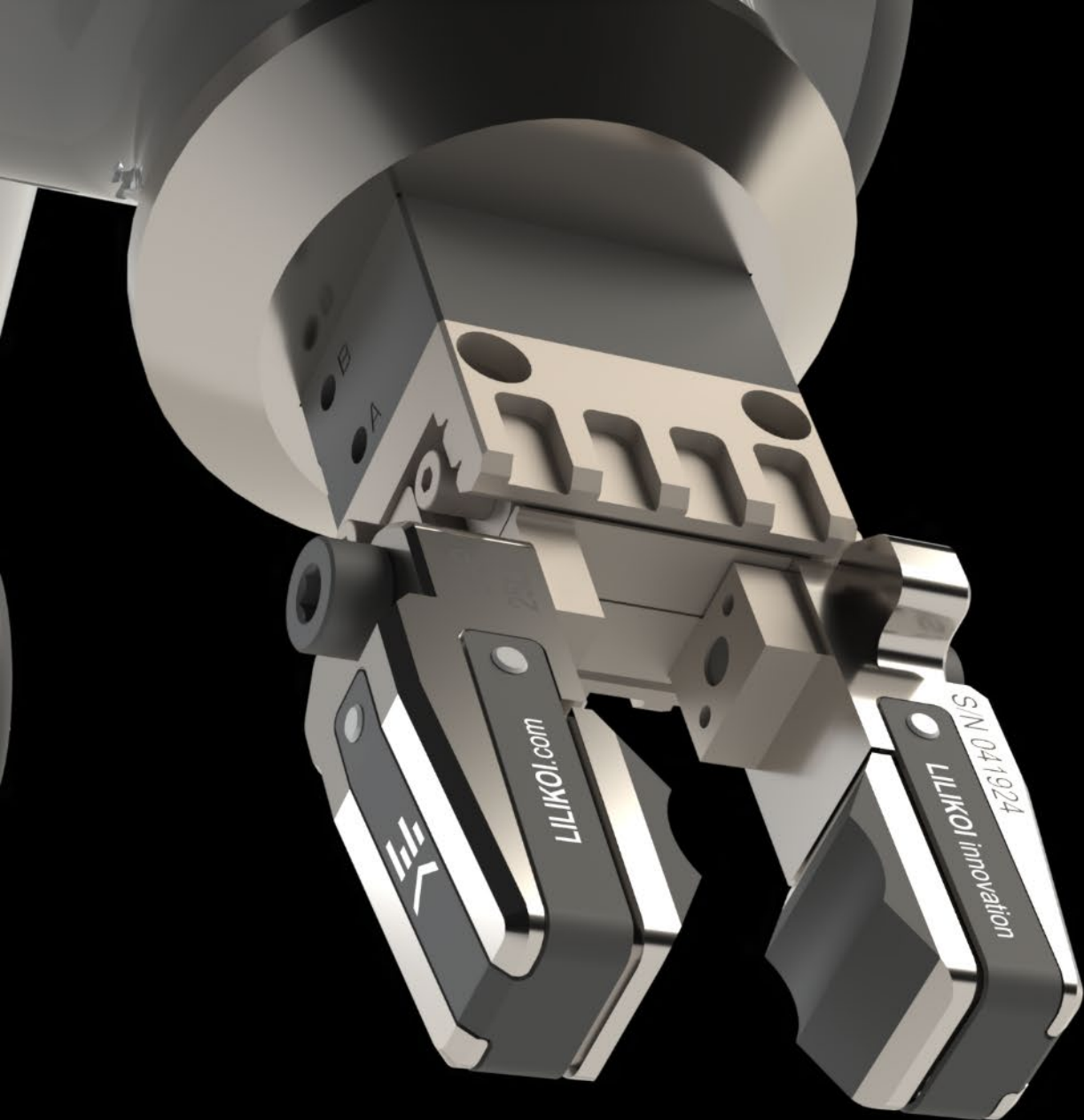
**SPECIFICATION:**

- CAPACITY:** 11.3 KG [25 LB]
- OUTPUT ( $\mu\epsilon$ ):** 3500 at FS nom.
- FORCE FBG WL [nm]:** 838 (T) & 878 (C)
- FIBER OP WL [nm]:** 830
- NON-LINEARITY:** 0.5% R.O.
- OPERATING TEMP:** -55°C[-67°F] to 200°C[392°F]
- TEMP SHIFT ZERO:** +/- 0.005% R.O./°C
- TEMP SHIFT SPAN:** +/- 0.002% R.O./°C
- SENSOR BODY:** STAINLESS STEEL
- CABLE LENGTH:** 1m [3.3ft]
- CABLE JACKET:** 1.6mm GLASS TEXTILE
- CONNECTOR:** OPTICAL FC

**ITEM#: LLK-0001**

# LILIKOI innovation

## TACTILE SENSORS



### GR25 GRIPPER FINGER

PATENT PENDING



### *IMMUNITY SERIES:*

- EMI & HIGH TEMPERATURE IMMUNITY
- TEMPERATURE COMPENSATION
- HIGH ACCURACY FORCE MEASUREMENT
- FEMTO MINIATURE PACKAGING

# TACTILE FINGER FORCE SENSORS

PATENT PENDING



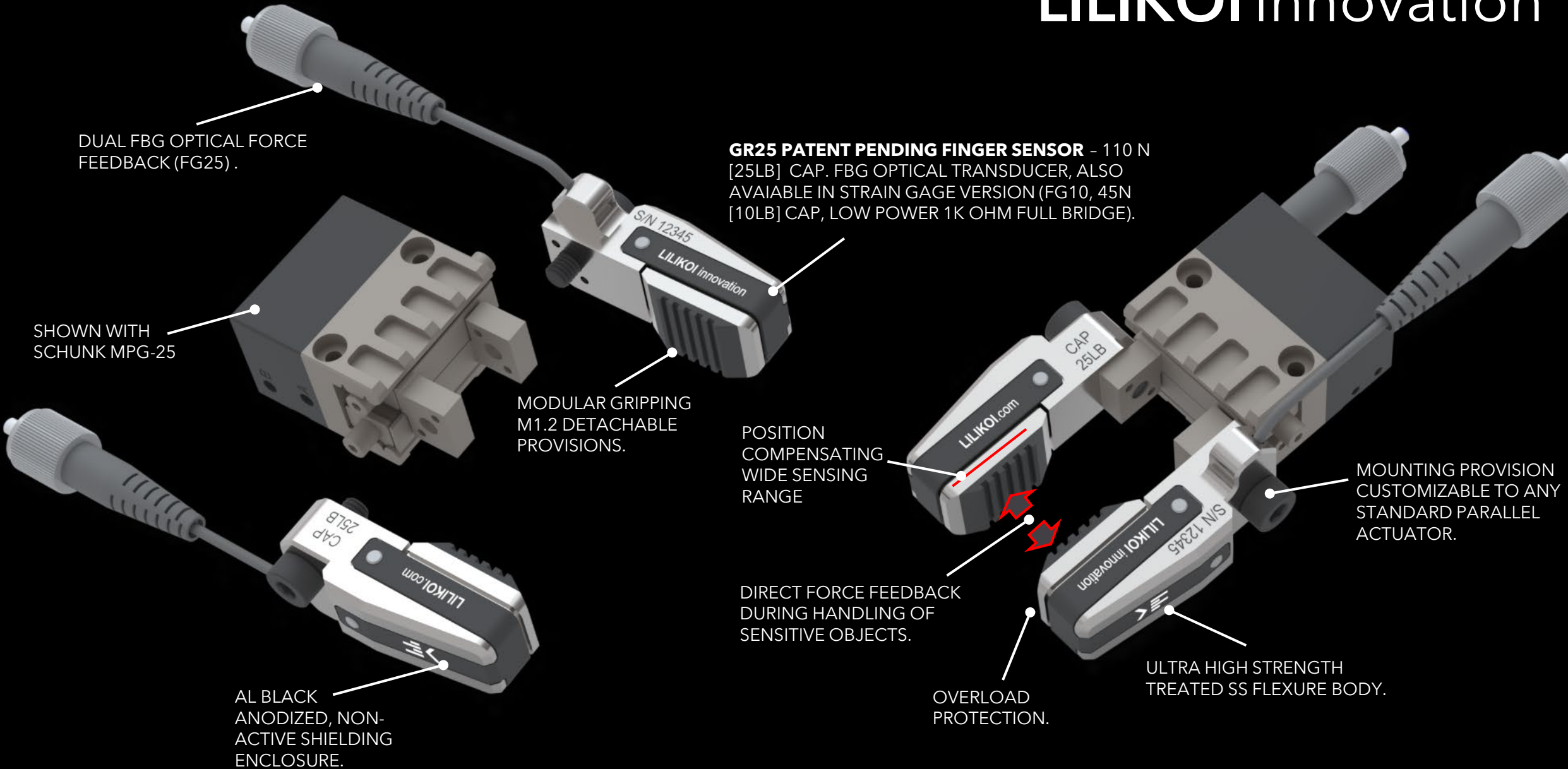
**GR25**

FBG OPTICAL FINGER  
FORCE SENSOR

**GR10**

STRAIN GAUGE FINGER  
FORCE SENSOR

# LILIKOI innovation



DUAL FBG OPTICAL FORCE FEEDBACK (FG25) .

**GR25 PATENT PENDING FINGER SENSOR** - 110 N [25LB] CAP. FBG OPTICAL TRANSDUCER, ALSO AVAILABLE IN STRAIN GAGE VERSION (FG10, 45N [10LB] CAP, LOW POWER 1K OHM FULL BRIDGE).

SHOWN WITH SCHUNK MPG-25

MODULAR GRIPPING M1.2 DETACHABLE PROVISIONS.

POSITION COMPENSATING WIDE SENSING RANGE

DIRECT FORCE FEEDBACK DURING HANDLING OF SENSITIVE OBJECTS.

OVERLOAD PROTECTION.

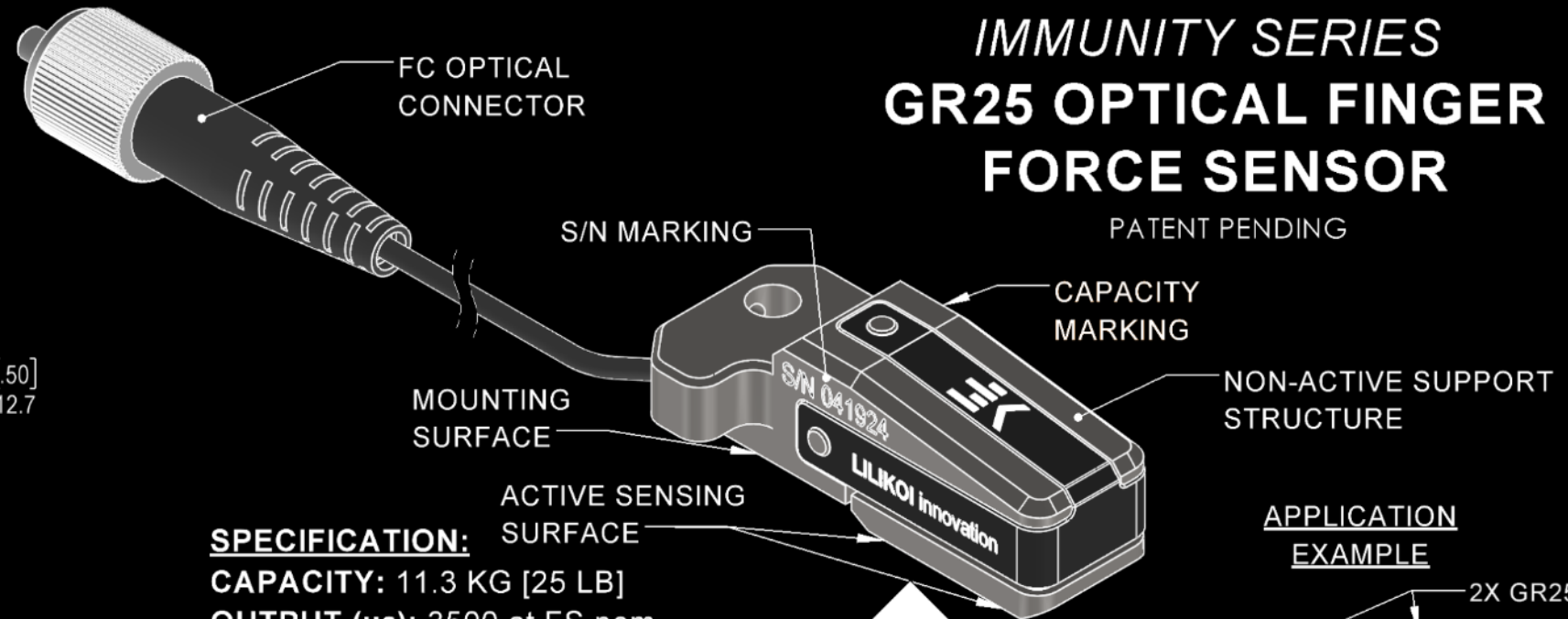
ULTRA HIGH STRENGTH TREATED SS FLEXURE BODY.

MOUNTING PROVISION CUSTOMIZABLE TO ANY STANDARD PARALLEL ACTUATOR.

AL BLACK ANODIZED, NON-ACTIVE SHIELDING ENCLOSURE.

# IMMUNITY SERIES GR25 OPTICAL FINGER FORCE SENSOR

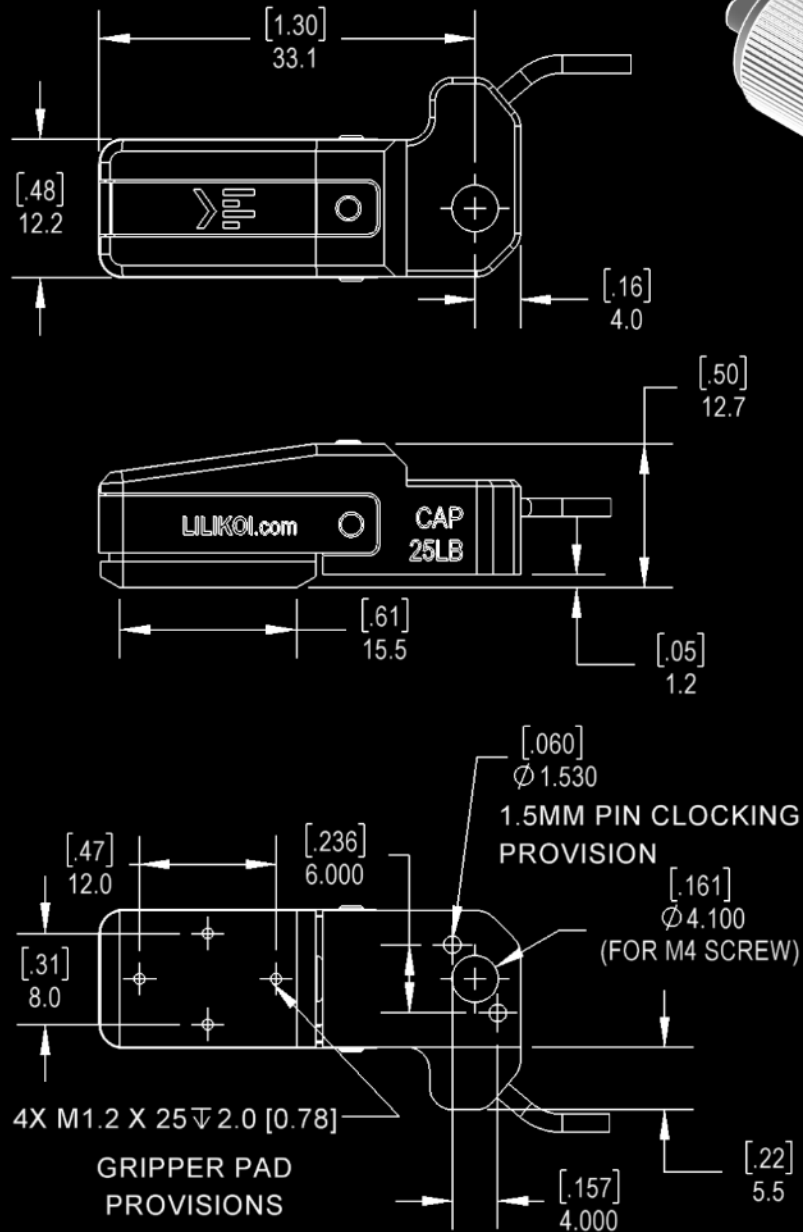
PATENT PENDING



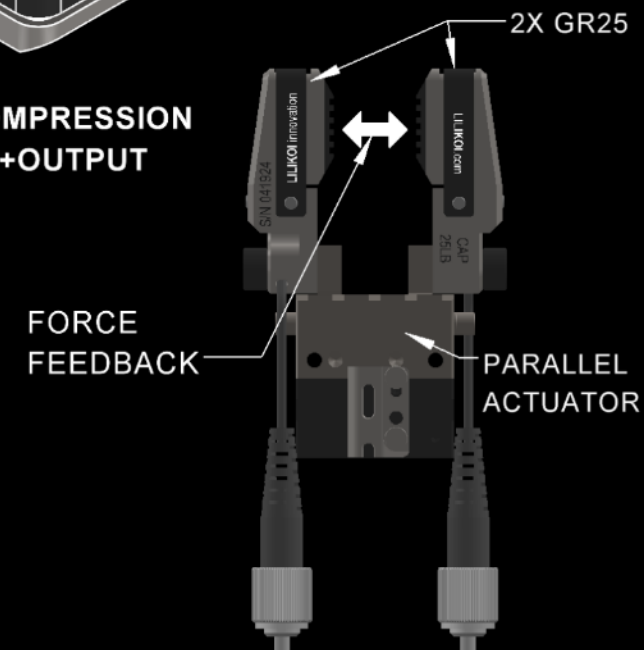
### SPECIFICATION:

- CAPACITY:** 11.3 KG [25 LB]
- OUTPUT ( $\mu\epsilon$ ):** 3500 at FS nom.
- DEFLECTION:** 0.25 [0.009]
- SAFE OVERLOAD:** 200%
- FORCE FBG WL [nm]:** 838 (T) & 878 (C)
- FIBER OP WL [nm]:** 830
- NON-LINEARITY:** 0.5% R.O.
- OPERATING TEMP:** -55°C [-67°F] to 200°C [392°F]
- TEMP SHIFT ZERO:** +/- 0.005% R.O./°C
- TEMP SHIFT SPAN:** +/- 0.002% R.O./°C
- SENSOR BODY:** STAINLESS STEEL
- CABLE LENGTH:** 1m [3.3ft]
- CABLE JACKET:**  $\phi$  1.6mm GLASS TEXTILE
- CONNECTOR:** OPTICAL FC

ITEM#: LLK-0007



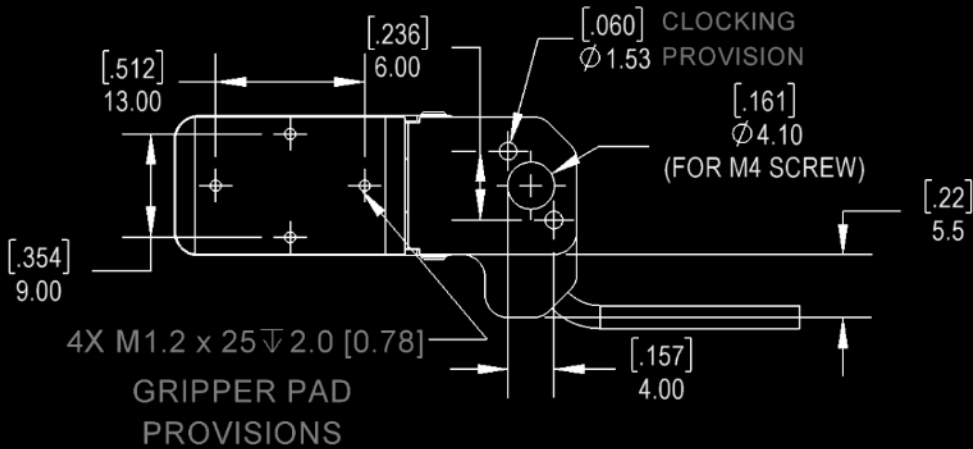
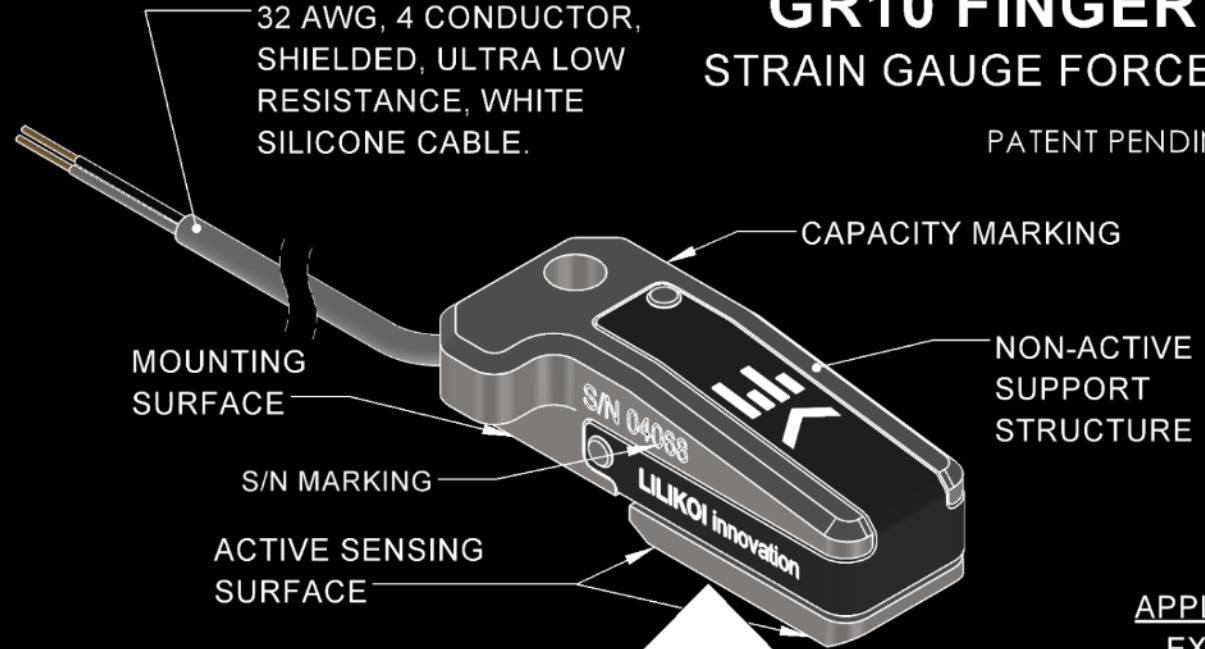
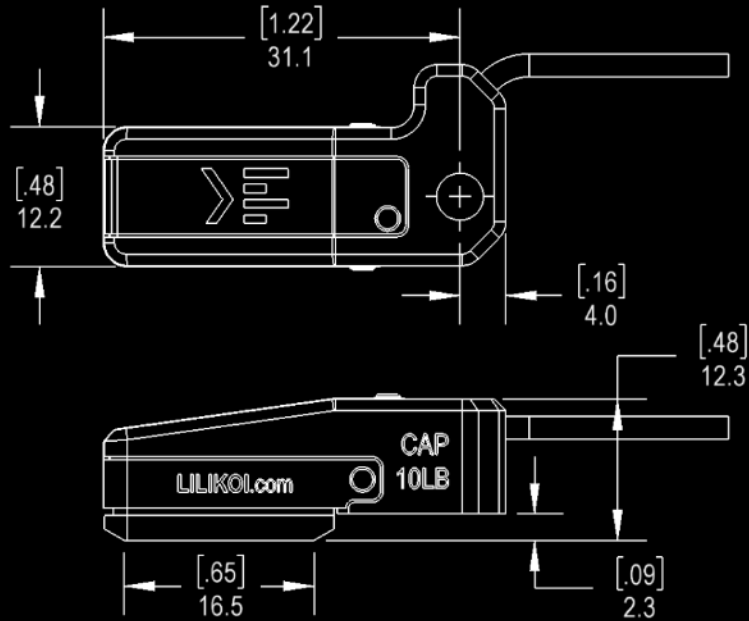
### APPLICATION EXAMPLE



COMPRESSION  
+OUTPUT

# GR10 FINGER SENSOR STRAIN GAUGE FORCE TRANSDUCER

PATENT PENDING



## WIRING CODE

+Excitation	-Excitation	+Signal	-Signal
RED	BLACK	GREEN	WHITE

## SPECIFICATION\*:

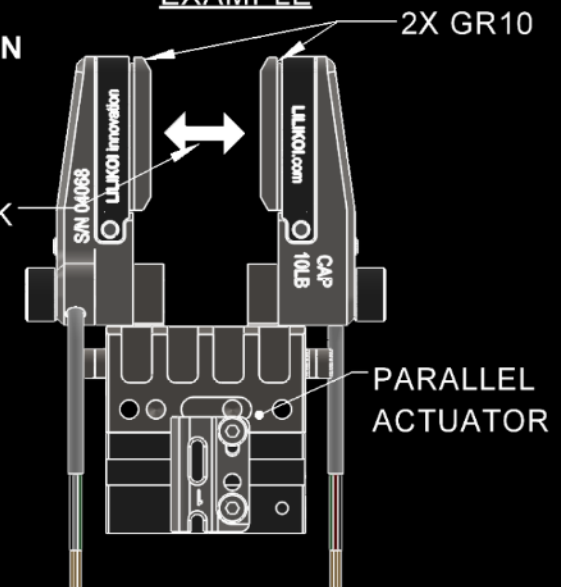
**CAPACITY:** 4.5 KG [10 LB]  
**RATED OUTPUT:** 2mV/V  
**NON-LINEARITY:** 0.1% R.O.  
**DEFLECTION:** 0.10 [0.009]  
**SAFE OVERLOAD:** 400%  
**BRIDGE RESISTANCE:** 1000 Ohm  
**OPERATING TEMP:** -51-71°C [-60-160°F]  
**TEMP SHIFT ZERO:** 0.01% R.O./degC  
**SENSOR BODY:** STAINLESS STEEL  
**CABLE LENGTH:** 2m [6.5ft]  
**CABLE TERMINATION:** PIGTAIL

ITEM#: LLK-0006

COMPRESSION  
+OUTPUT

FORCE  
FEEDBACK

## APPLICATION EXAMPLE



# *GS05*

*IMMUNITY SERIES*

PATENT PENDING

DUAL FBG FEMTO OPTICAL GRASPER

FINGER FORCE SENSOR



*LILIKO*innovation



# IMMUNITY SERIES GS05 OPTICAL GRASPER FORCE SENSOR

PATENT PENDING





# TRANSFORMING THE LANDSCAPE

Aluminum T-Slot Extrusion Integration



## LILIKOI innovation

### SMART BRACKETS

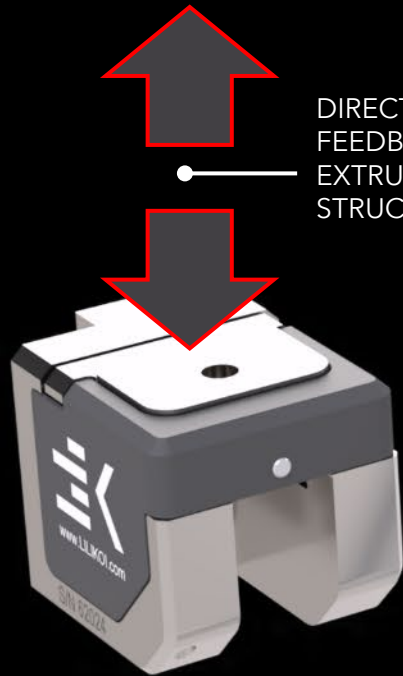
Strain Gauge Force Sensors



# LILIKOI innovation

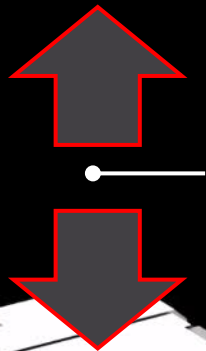
## SMART BRACKETS

Strain Gauge Force Sensors

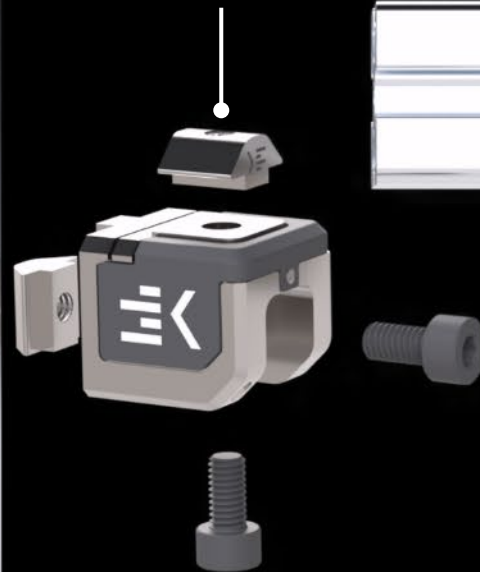


**SB30**  
30MM EXTRUSION

DIRECT FORCE  
FEEDBACK FROM  
EXTRUSION  
STRUCTURE.

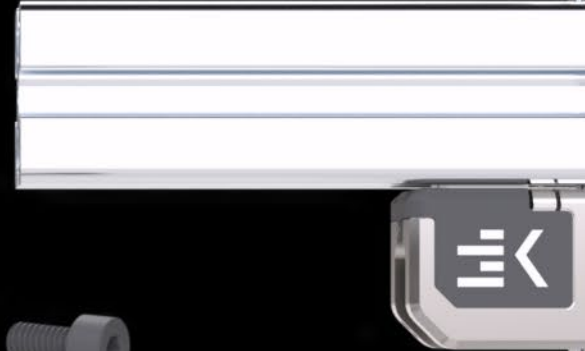
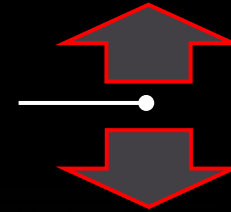


DROP-IN REPLACEMENT  
INTO STANDARD  
EXTRUSION SYSTEMS



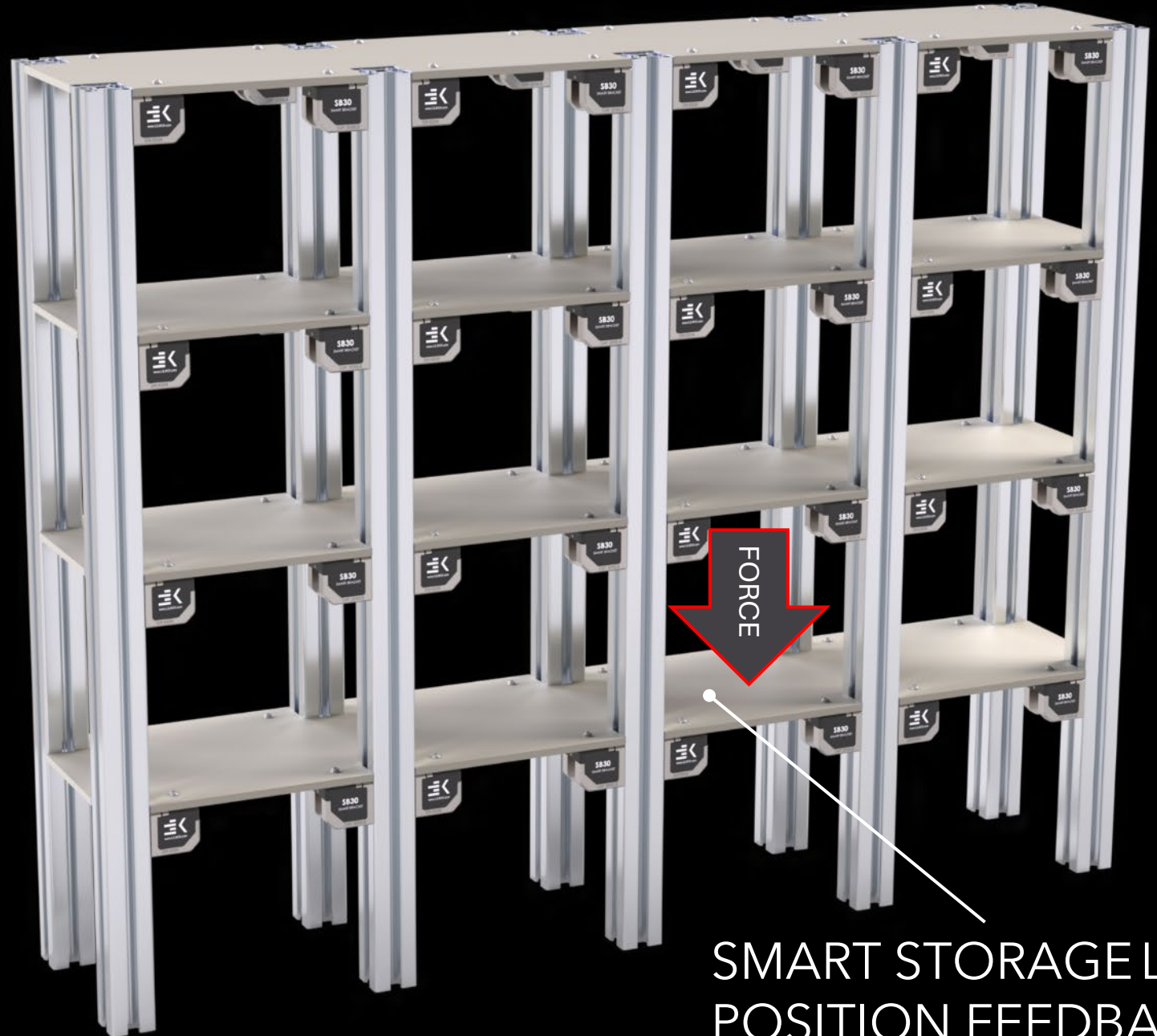
**SB20**  
20MM EXTRUSION

DIRECT FORCE  
FEEDBACK FROM  
EXTRUSION  
STRUCTURE.

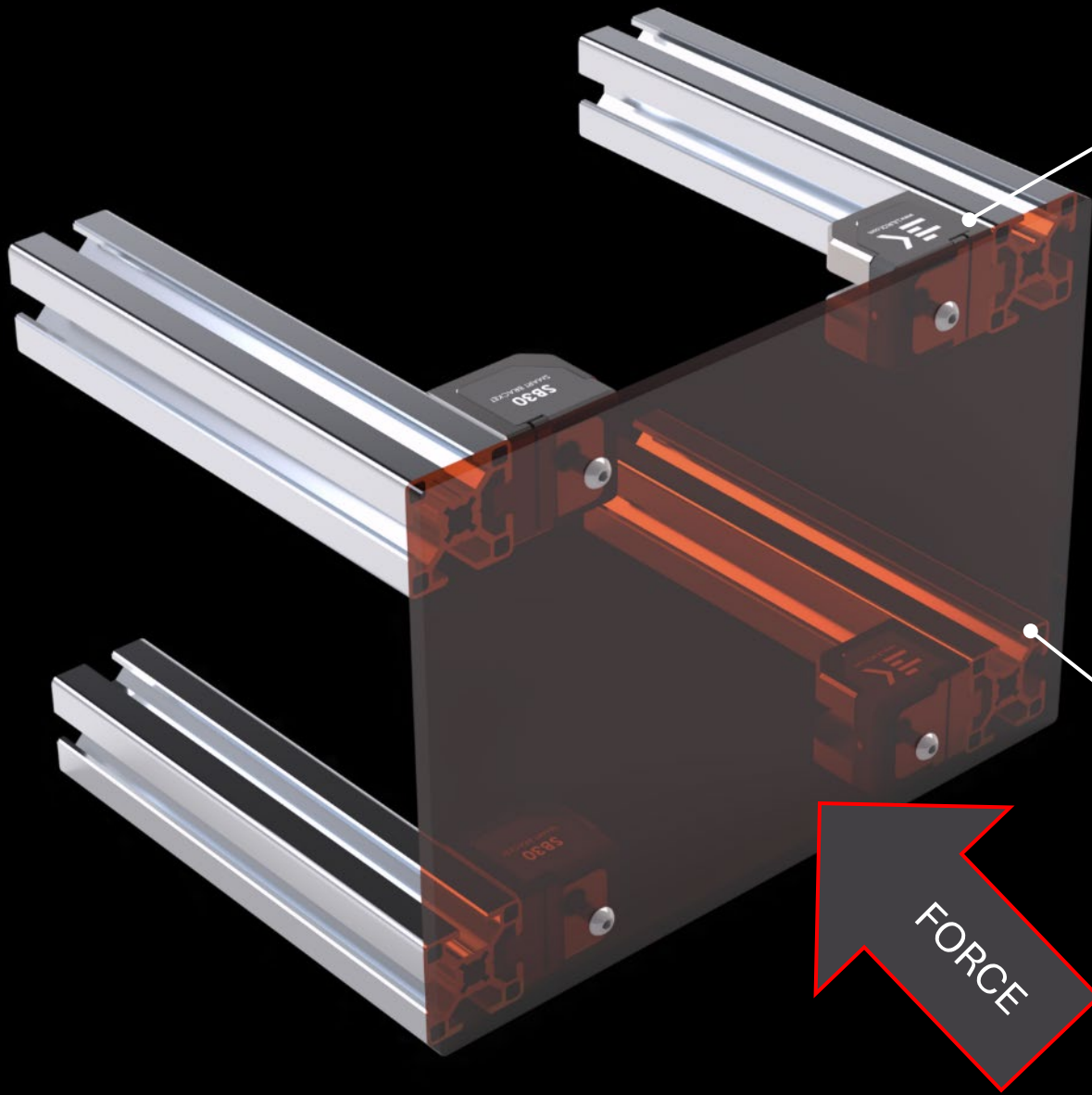


## T-Slot Extrusion Integration

LILIKOI innovation  
T-Slot Extrusion Integration  
SMART BRACKETS



SMART STORAGE LOAD &  
POSITION FEEDBACK



# LILIKOI innovation

## SMART BRACKETS

Strain Gauge Force Sensor

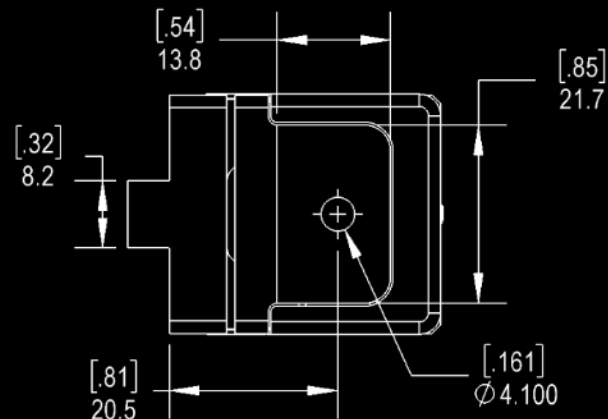
SMART PANEL  
FORCE FEEDBACK



# SB30 SMART BRACKET

## STRAIN GAUGE FORCE SENSOR

PATENT PENDING



MOUNTING SURFACE

+/- DIRECTIONAL OUTPUT

LOADING SURFACE

S/N MARKING

CAPACITY MARKING

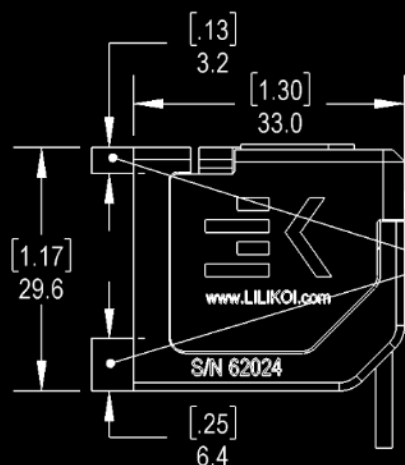
32AWG, 4 CONDUCTOR SHIELDED, WHITE SILICONE CABLE 2MM OD NOM.

30MM SLOTTED EXTRUSION

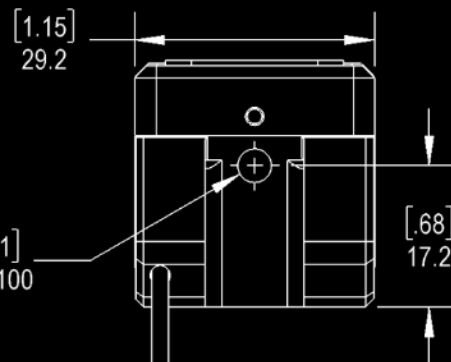
SB30 INTEGRATION

FORCE FEEDBACK

APPLICATION EXAMPLE



CLOCKING TABS



### WIRING CODE

+Excitation	-Excitation	+Signal	-Signal
RED	BLACK	GREEN	WHITE

### SPECIFICATION\*:

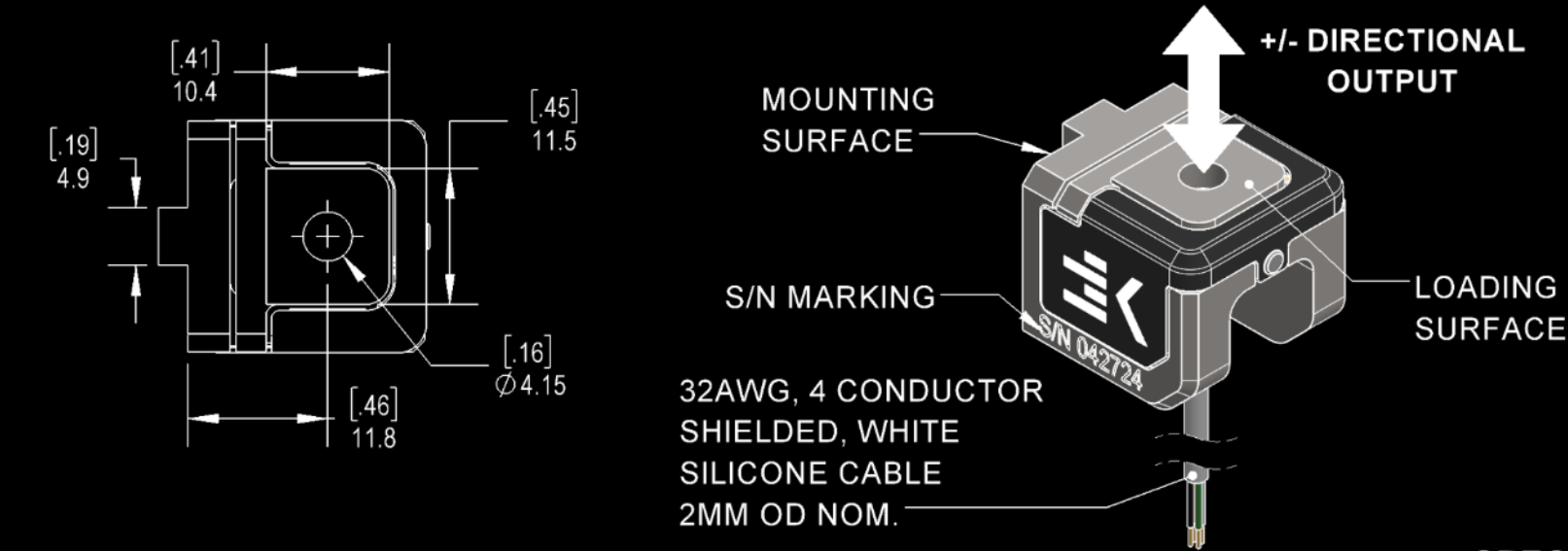
**CAPACITY:** SEE CHART  
**RATED OUTPUT:** SEE CHART  
**NON-LINEARITY:** 0.1% R.O.  
**DEFLECTION:** 0.25 [0.009]  
**SAFE OVERLOAD:** 400%  
**BRIDGE RESISTANCE:** 1000 Ohm  
**OPERATING TEMP:** -51-71°C [-60-160°F]  
**TEMP SHIFT ZERO:** 0.01% R.O./degC  
**SENSOR BODY:** STAINLESS STEEL  
**CABLE LENGTH:** 2m [6.5ft]  
**CABLE TERMINATION:** PIGTAIL

ITEM #	CAP (KG [LB])	R.O. [mV/V]
LLK-0002	11.3 [25]	1.25
LLK-0003	22.7 [50]	2.5

# SB20 SMART BRACKET

## STRAIN GAUGE FORCE SENSOR

PATENT PENDING

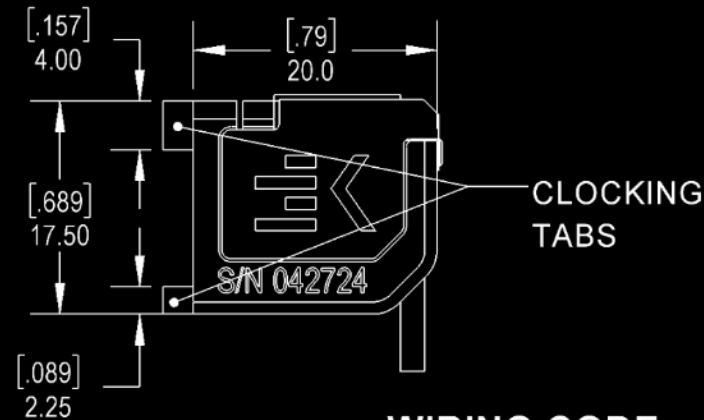


20MM SLOTTED  
EXTRUSION

SB20  
INTEGRATION

FORCE  
FEEDBACK

APPLICATION  
EXAMPLE



### WIRING CODE

+Excitation	-Excitation	+Signal	-Signal
RED	BLACK	GREEN	WHITE

### SPECIFICATION\*:

CAPACITY: 11.3 KG [25 LB]

RATED OUTPUT: 2mV/V

NON-LINEARITY: 0.1% R.O.

DEFLECTION: 0.25 [0.009]

SAFE OVERLOAD: 400%

BRIDGE RESISTANCE: 350 Ohm

OPERATING TEMP: -51-71°C [-60-160°F]

TEMP SHIFT ZERO: 0.01% R.O./degC

SENSOR BODY: STAINLESS STEEL

CABLE LENGTH: 2m [6.5ft]

CABLE TERMINATION: PIGTAIL

ITEM#: LLK-0004

# Questions?

Visit Booth 615 for FBG and Force Sensor Demonstrations



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