Anexos

1. Catálogos

1.1.Catálogo nanoposicionador

npoint

nanopositioning | motion control

NPXY100Z10A

Specifications

Range (µm)	100 x 100 x 10
Footprint (mm)	140 x 140 x 30
Aperture (mm)	68 x 68
Material	Aluminum
Max Load (kg)	1

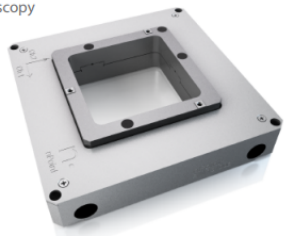
The NPXY100Z10A is a closed-loop XYZ nanopositioner with 100µm x 100µm x 10µm range of motion. It has the highest resonant frequency available in the market for products of similar function. Its large aperture allows for easy integration with optical microscopes or any application that requires easy sample access.

	XY	Z
Position Noise (nm)	0.5	0.1
Small Signal Settling Time (ms/1µm step)	15	7
Resonant Frequency (Hz, unloaded, typical)	600	1600
Linearity Error (%)	0.05	0.5
Hysteresis (%, typical)	0.05	0.5

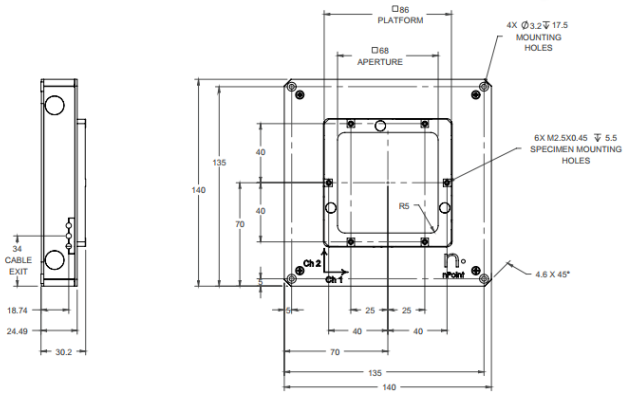
Part Number 3715128

Application Examples

- Near-Field Scanning Optical Microscopy
- Scanning Probe Microscopy
- Optical Microscopy
- Lithography
- Nanometer-scale Manipulation
- Metrology
- Optical Fiber Alignment



Installation



www.npoint.com
sales@npoint.com
sales: 608.824.1770
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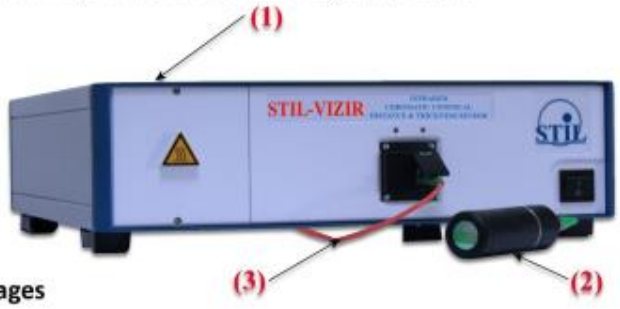
3030 Laura Ln., #100
Middleton, WI 53562

Fuente [1]

1.2.Catálogo sensor confocal

Chromatic Confocal "point" sensors

These sensors measure the altitude (z coordinate) of the sample point located on their optical axis.
They can also measure the thickness of transparent samples.
They consist of a controller (1), an "optical pen" (optical probe) (2) and a fiber optic cable (3).
3 controller lines (CCS, STIL-VIZIR and CHR), 3 optical pen lines (CL-MG, OP & ENDO) and different fiber optic cable models are available.
A single controller may be ordered with several interchangeable optical pens.



Advantages

- Configurable: Select the controller, the optical pen and the fiber optics cable best suited for your application.
- Large choice of measuring ranges (100 µm - 20 mm),
- Large choice of optical pens satisfying specific requirements ("endoscopic" / radial pens / large working distance / steep slope / small spot size / through-window measurement...).

Controllers for chromatic confocal "point" sensors

The CCS Controller line

- The leading confocal chromatic sensors worldwide,
- The most sophisticated chromatic confocal sensors on the market,
- Distance and Thickness modes,
- High accuracy, high resolution,
- Compatible with all CL-MG, OP and ENDO optical pens,
- Recommended for OEM users and industrial applications,
- Up to 20 different optical pens interchangeable on the same controller,
- Digital outputs: USB and RS232 / RS422,
- 2 0V-10V Analog outputs,
- Synchronized reading of 3 external digital encoders,
- Improved performances in thickness mode due to a specific thickness calibration,
- Long lifetime light source,
- Advanced features: "Auto-Led", "First peak", "Double frequency", "Hold last value", Temporal Averaging....
- Synchronisation: Master and/or slave

Functions	Application
"Auto-LED": The LED brightness adapts itself automatically	Samples with variations slope e.g lenses Samples with reflectivity variations
"First peak": The sensor locks on the first surface	Topography on transparent objets
"Double Frequency": The sensor selects the optimal measuring rate automatically	Samples with high sharp relectivity variations, e.g. mask for microelectronics
"Hold Last Value": Output data smoothing	Very difficult samples with many non measurable points

Non-conctact "point" sensors

The CCS Optima+ Controller

- New 2014 product
- Measuring rate: up to 10 KHz
- Very high sensitivity, allowing an EFFECTIVE high rate on many sample types
- All the advantages of the CCS controller line (see page 7)

The CCS Prima Controller

- The most popular chromatic confocal controller
- Measuring rate: up to 2 KHz
- CCD photodetector with very high Signal to noise ratio
- 2 and 4 multiplexed channels models available (commutation time < 400ms)
- All the advantages of the CCS controller line (see page 7)

www.stilsa.com - Phone:+33 4 42 39 66 51
contact@stilsa.com - 595, rue Pierre Berthier - Domaine de Saint Hilaire - 13855 Aix en Provence - Cedex3 - FRANCE

The STIL-VIZIR Controller

- New 2014 product
- The optimal solution for high accuracy, non contact Wafer thickness measurement
- Near IR spectral bande
- Up to 1 KHz
- Distance and Thickness modes
- Digital outputs: USB and RS232/RS422
- 2 0V-10V Analog outputs
- Synchronized reading of 3 external digital encoders
- Improved performances in thickness mode due to a specific Thickness calibration
- Long lifetime light source
- Advanced features: "First peak", "double frequency", "Hold last value", Temporal Averaging... (see page 7)

The CHR-150L Controller line

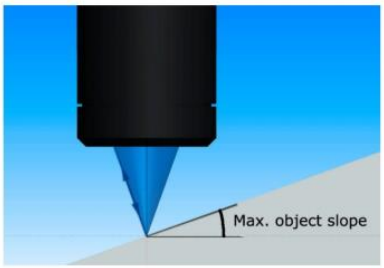
- Measuring rate: up to 1 KHz
- Compatible with all CL-MG, OP and ENDO optical pens
- Digital outputs: 2 RS232 ports (up to 115200 baud)
- 2 Analog outputs
- Long lifetime light source (light level adjustable manually with the aid of a knob)
- 2 or 4 silmultaneous channels

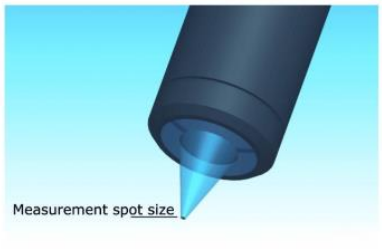
Optical pens for chromatic confocal "point" sensors

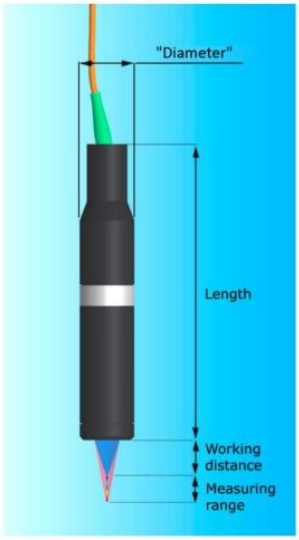
- The CL-MG Line consists of modular optical pens, comprising a chromatic lens (CL) and a magnifier lens (MG)
- Performance specifications supply for optical pens calibrated on STIL certified bench for a particular controller

CL-MG Line Specifications for CCS Optima+ Controller															
Model		CL0[15]		CL1		CL2			CL3		CL4		CL5		CL6
Measuring range[1]	µm	100		150		400			1300		4000		12000		24000
Working distance[2]	mm	2.69		3.35		10.8			12.0		16.2		25.9		21.5
Max. sample slope[3]	deg	±42°		±42.5°		±28°			±25°		±21°		±14°		±8.5°
Reference plate[4]	-	No		No		Yes			Yes		Yes		Yes		No
Axial model[5]	-	Standard													
Radial model[5]	-	Optional													
Magnifier model		MG 210	MG 140	MG 210	MG 140	MG 210	MG 140	MG 70	MG 140	MG 70	MG 35	MG 20	MG 35	MG 20	MG 35	MG 20
NUMERICAL APERTURE																
Beginning of M.R.	-	0.76	0.76	0.72	0.72	0.47	0.47	0.47	0.43	0.43	0.35	0.35	0.25	0.25	0.19	0.19
Mid-range	-	0.75	0.75	0.71	0.71	0.46	0.46	0.46	0.41	0.41	0.33	0.33	0.21	0.21	0.14	0.14
End of M.R.	-	0.75	0.75	0.71	0.71	0.46	0.46	0.46	0.41	0.41	0.32	0.32	0.20	0.20	0.12	0.12
LATERAL (XY) PROPERTIES																
Spot size[12]																
Beginning of MR	µm	1.6	2.0	2.4	3.2	3.5	4.6	8.1	6.0	10.8	10.7	17.6	19.6	32.8	18.6	30.5
Center of MR	µm	1.8	2.2	2.7	3.5	4.0	5.2	8.8	6.8	11.9	12.3	19.9	24.3	40.0	26.8	43.0
End of MR	µm	1.9	2.4	3.0	3.8	4.4	5.7	9.3	7.4	12.6	13.4	21.3	27.2	44.2	32.7	51.4
Lateral resolution[6]	µm	1.1	1.0	1.1	1.3	1.7	1.8	3.7	2.6	4.5	4.6	7.0	11	14	11	18
PHOTOMETRIC EFFICIENCY[7]																
Collected energy (relative)		0.5	1.7	3.3	10	2.8	7.9	41	10	57	25	91	33	100	9.8	43
MECHANICAL INTERFACE																
Length[8]	mm	263.6	229	253.1	217.1	243.3	208.9	176.1	205.9	176.1	145.5	131.7	145.5	131.7	167.6	151.8
Diameter	mm	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Weight[8]	g	227	192	268	195	248	190	189	215	214	155	140	175	160	195	180
Performances																
DISTANCE MEASUREMENT																
Static Noise[9]																
With no averaging	nm	5.5	6.5	7.5	8.5	17	20	28	50	60	120	145	400	475	750	850
With averaging 10	nm	1.8	2.2	2.5	2.8	5.7	6.7	9.3	17	20	40	48	133	158	250	283
Accuracy[10]	nm	16	14	25	20	55	45	40	150	130	300	250	750	550	1600	1200
Measuring rough metal surfaces[11]	-	R	R	R	R	R	R	R	R	NR	NR	NR	NR	NR	NR	NR
THICKNESS MEASUREMENT[13]																
Min. measurable thick[14]	µm	≤5	≤5	7.5	9	14	14	22	38	40	110	120	350	550	590	725
Max. measurable thick[14]	µm	≤100	≤100	175	175	510	510	510	2000	2000	5700	5700	16500	16500	34000	34000

For notes see page 15







Fuente [2]

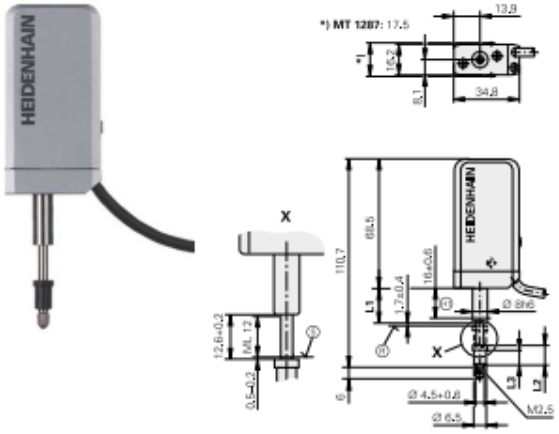
1.3.Catálogo sensor Heidenhain

HEIDENHAIN-METRO

Incremental length gauges with ± 0.2 µm accuracy

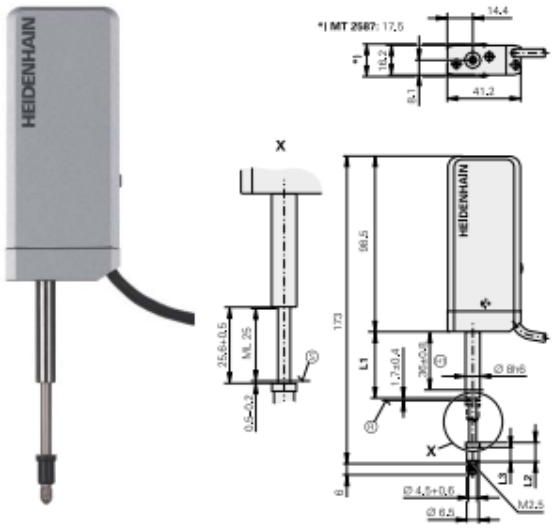
- **High repeatability**
- **Plunger actuation by cable release, by the workpiece or pneumatically**
- **Ball-bush guided plunger**

MT 1200



	MT 12x1	MT 1287
L1	18.5	22.0
L2	10.1	6.2
L3	8.1	4.2

MT 2500



	MT 25x1	MT 2587
L1	37.0	41.0
L2	10.1	6.2
L3	8.1	4.2

MT 1287
MT 2587

mm

Tolerancing ISO 8015
ISO 2768 - m H
< 6 mm: ±0.2 mm

① = Reference mark position
② = Beginning of measuring length
③ = Clamping area
④ = Air connection for 2 mm tube

Mechanical data	MT 1271 ⊓⊔ TTL MT 1281 ∿ 1 V_{PP}	MT 2571 ⊓⊔ TTL MT 2581 ∿ 1 V_{PP}	MT 1287 ∿ 1 V_{PP}	MT 2587 ∿ 1 V_{PP}
Plunger actuation Position of plunger at rest	By cable or measured object Extended		Pneumatic Retracted	
Measuring standard	DIADUR phase grating on Zerodur glass ceramic; grating period 4 µm			
System accuracy	± 0.2 µm			
Position error per signal period	≤ ± 0.02 µm			
Short-range accuracy typically	0.03 µm	0.04 µm	0.03 µm	0.04 µm
Reference mark	≈ 1.7 mm below upper stop			
Measuring range	12 mm	25 mm	12 mm	25 mm
Working pressure	–		0.9 bar to 1.4 bars	
Radial force	≤ 0.8 N (mechanically permissible)			
Fastening	Clamping shank Ø 8h6			
Operating attitude	Any; *for version without spring and with low gauging force:* vertically downward			
Vibration 55 Hz to 2 000 Hz **Shock** 11 ms	≤ 100 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27)			
Operating temperature	10 °C to 40 °C; reference temperature 20 °C			
Protection EN 60 529	IP50		IP64 (with sealing air)	
Weight without cable	100 g	180 g	110 g	190 g

Electrical data	MT 1271 MT 2571		MT 128x MT 258x
Interface	⊓⊔ TTL		∿ 1 V_{PP}
Integrated interpolation*	5-fold	10-fold	–
Signal period	0.4 µm	0.2 µm	2 µm
Mech. permissible traversing speed	≤ 30 m/min		
Edge separation a at scanning frequency*/traverse speed[1)] 200 kHz ≤ 24 m/min 100 kHz ≤ 12 m/min 50 kHz ≤ 6 m/min 25 kHz ≤ 3 m/min	 ≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs –	 – ≥ 0.23 µs ≥ 0.48 µs ≥ 0.98 µs	 –
Electrical connection* (Interface electronics integrated in connector)	Cable 1.5 m with D-sub connector (male), 15-pin		Cable 1.5 m with • D-sub connector (male), 15-pin • M23 connector (male), 12-pin
Cable length	≤ 30 m with HEIDENHAIN cable		
Voltage supply	5 V DC ± 0.5 V/< 160 mA (without load)		5 V DC ± 0.25 V/< 130 mA

* Please select when ordering 1) At the corresponding cutoff or scanning frequency

Fuente [3]

1.4.Catálogo posicionadora

PI

Precision Linear Stage

COMPACT DESIGN, FOR LOADS UP TO 10 KG

L-509

- Travel ranges from 26 to 102 mm (1" to 4")
- Repeatability to 0.05 µm
- Optional direct metrology linear encoder
- Stepper Motor or DC Gear Motor
- Direction- sensing reference point switch
- Integrated optical limit switches

Reference- class linear stage
High travel accuracy and load capacity due to crossed roller guides. Precision ball screw with 1 mm pitch. Compact design. Stress- relieved aluminum base for highest stability. Optical limit switches. Travel ranges L-509.2 versions: 26 mm (1"), L-509.4: 52 mm (2"), L-509.6: 102 mm (4")

Drive types

- .xxDG variant: DC servo motor with gearhead for high torques and resolution at low motor power
- .xxSD variant: 2- phase stepper motor for low velocity and high resolution

Noncontact limit switches. Noncontact, direction- sensing reference point switch in the middle of the travel range

Position measurement

- Integrated rotary encoder on motor shaft (variants with DC gear motor).
- Laterally mounted linear encoder. Direct position measurement of moved platform without impact on positioning precision due to mechanical play or hysteresis in the drive

Min. incremental motion and slow motion
In conjunction with the SMC Hydra controller, versions with stepper motor and integrated linear encoder (L-509.xASD00) achieve repeatable minimum incremental motion in the range of the sensor resolution. With this configuration, constant, low velocities of a few sensor steps per second can be attained

Fields of application
Precision positioning for science and industry, high duty cycles.

L-511 and L-509 precision stages can be combined without adapter plates for positioning on several axes.

Multi- axis setup consisting of L-511 (horizontal) and L-509 (vertical) precision stages.

Specifications

Preliminary Data	L-509.x0DG10	L-509.xASD00	L-509.x0SD00	Unit	Tolerance
	Linear stage with DC gear motor and rotary encoder	Linear stage with stepper motor and linear encoder (direct position measurement)	Linear stage with stepper motor		
Motion and Positioning					
Travel range #	26 / 52 / 102	26 / 52 / 102	26 / 52 / 102	mm	
Integrated sensor	Rotary encoder	Linear encoder	–		
Sensor resolution rotary encoder	4096	–	–	cts./ rev.	typ.
Sensor resolution linear encoder	–	1##	–	nm	typ.
Minimum incremental motion	0.1	0.01	0.315*	µm	typ.
Unidirectional repeatability	0.1	0.1	0.3	µm	typ.
Backlash	0.3	0.1	0.5	µm	typ.
Crosstalk, angular error xry (pitch)	±120	±120	±120	µrad per 100 mm travel	typ.
Crosstalk, angular error xrz (yaw)	±100	±100	±100	µrad per 100 mm travel	typ.
Max. velocity	3	20	20	mm/ s	
Min. velocity	–	0.05	–	mm/ s	
Mechanical Properties					
Thread/ spindle pitch	1	1	1	mm	
Gear ratio	2401:81	–	–		
Load capacity	100	100	100	N	max.
Push / pull force	60	60	60	N	max.
Lateral force	50	50	50	N	max.
Holding force	40	80	80	N	max.
Drive Properties					
Motor type	DC gear motor	2- phase stepper motor	2- phase stepper motor		
Operating voltage	0 to ±12	24	24	V	
Motor power	8.5	10	10	W	nominal
Reference point and limit switches	Optical	Optical	Optical		
Miscellaneous					
Operating temperature range	-20 to 65	-20 to 65	-20 to 65	°C	
Material	Aluminum, steel	Aluminum, steel	Aluminum, steel		
Mass	1.4 / 1.6 / 1.9	1.4 / 1.6 / 1.9	1.4 / 1.6 / 1.9	kg	± 5%
Connector	HD Sub- D 26- pin (motor and rotary encoder) to Sub- D 15- pin, 3 m cable	HD Sub- D 26- ppin (motor), Sub- D 9- pin (linear encoder), 3 m cable set	HD Sub- D 26- pin (motor) to Sub- D 15- pin, 3 m cable		
Recommended controller/ driver	C-863 (single- axis), C-884 (up to 4 axes)	SMC Hydra (double- axis)	C-663 (single- axis)		

Order Information

L-509.10DG10
Precision Linear Stage, 85 mm Wide, DC Gear Motor, 26 mm (1") Travel Range, Optical Limit Switches
L-509.10SD00
Precision Linear Stage, 85 mm Wide, 2- Phase Stepper Motor, 26 mm (1") Travel Range, Optical Limit Switches
L-509.20DG10
Precision Linear Stage, 85 mm Wide, DC Gear Motor, 52 mm (2") Travel Range, Optical Limit Switches
L-509.20SD00
Precision Linear Stage, 85 mm Wide, 2- Phase Stepper Motor, 52 mm (2") Travel Range, Optical Limit Switches
L-509.40DG10
Precision Linear Stage, 85 mm Wide, DC Gear Motor, 102 mm (4") Travel Range, Optical Limit Switches
L-509.40SD00
Precision Linear Stage, 85 mm Wide, 2- Phase Stepper Motor, 102 mm (4") Travel Range, Optical Limit Switches

Stages with direct position measurement

L-509.1ASD00
Precision Linear Stage, 85 mm Wide, 2- Phase Stepper Motor, 26 mm (1") Travel Range, Linear Encoder with Sin/ Cos Signal Transmission, Optical Limit Switches
L-509.2ASD00
Precision Linear Stage, 85 mm Wide, 2- Phase Stepper Motor, 52 mm (2") Travel Range, Linear Encoder with Sin/ Cos Signal Transmission, Optical Limit Switches
L-509.4ASD00
Precision Linear Stage, 85 mm Wide, 2- Phase Stepper Motor, 102 mm (4") Travel Range, Linear Encoder with Sin/ Cos Signal Transmission, Optical Limit Switches

Controllers / Drivers / Amplifiers

C-863 Mercury Servo Controller
C-863.20C885 DC Motor Controller Module
C-884 Four Axis Motion Controller
C-663 Mercury Step Controller
SMC hydra SMC- series
SMC pollux SMC- series

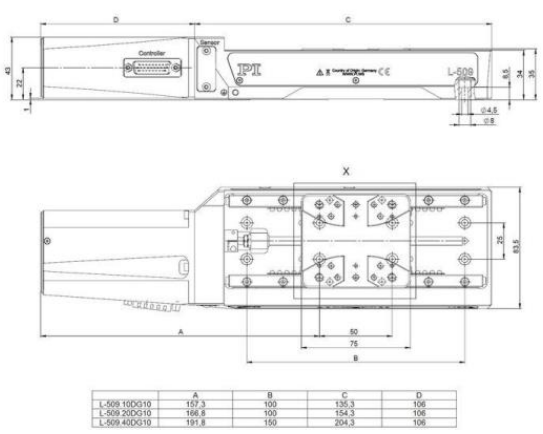
Accessories

L-500 Adapter Bracket

Related Products

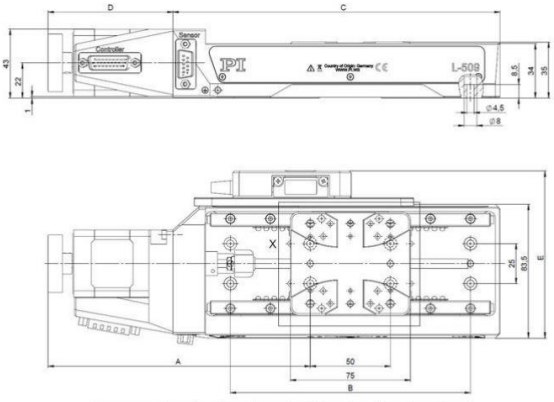
VT-80 Translation Stage
M-404 Precision Translation Stage
M-403 Precision Translation Stage
M-605 High- Accuracy Translation Stage
L-511 High- Precision Linear Positioning Stage
PLS-85 Precision Linear Stage

Drawings / Images



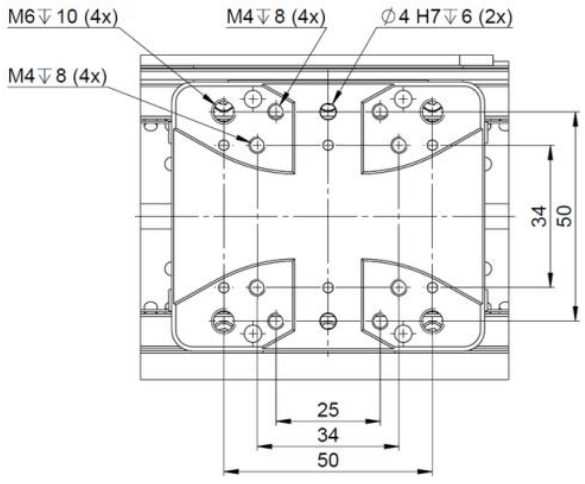
	A	B	C	D
L-509.10DG10	157.3	100	135.3	106
L-509.20DG10	166.8	100	154.3	106
L-509.40DG10	191.8	150	204.3	106

L-509 Versions with DC gear motor, dimensions in mm



	A	B	C	D	E
L-509.10SD00	129,3	100	135,3	78	-
L-509.1ASD00	129,3	100	135,3	78	104,2
L-509.20SD00	138,8	100	154,3	78	-
L-509.2ASD00	138,8	100	154,3	78	104,2
L-509.40SD00	163,8	150	204,3	78	-
L-509.4ASD00	163,8	150	204,3	78	104,2

L-509 Versions with stepper motor, dimensions in mm



L-509 slide detail drawing

Fuente [4]

1.5.Catálogo muestra patrón

Contour and roughness standards

Each measuring device is only as good as its reference. To monitor the precision and testing of contour measuring instruments, for instance in accordance with VDI/VDE 2629, we offer a wide range of contour and roughness standards.

Depending on the model, our standards are manufactured from hardened and aged gauge steel or hard metal.

As an additional option, our standards are also available with a nearly adamantine, extremely wear-resistant surface coating. Stable mounting blocks or mounts with precision tilt axes are available for safely supporting our standards.

KN180 contour standard

We can offer you the following test certificates for our standards

- Works certificate (standard)
- DAkkS certificate
- PTB test certificate

KN15 :: Micro contour standard

KN15

Fuente [5]

2. Elementos Finitos

2.1.Informe sensor confocal

La única carga impuesta fue la de la gravedad:

Tabla 1.Cargas impuestas en el modelo del conjunto sensor confocal. Fuente: SolidEdge

Nombre de carga	Tipo de carga	Valor de carga	Dirección de carga
Gravedad 1	Gravedad	981 cm/s^2	(0,0, 0,0, -1,0)

A continuación, se observan las características de cada componente del conjunto. Estas fueron impuestas en el momento del diseño de cada componente:

Tabla 2. Características componentes conjunto sensor confocal. Fuente: SolidEdge.

Nombre del sólido	Material	Masa (Kg)	Volumen (mm^3)	Peso (N)
Sensor con color.V.par:1	Acero, estructural (Ocurrencia)	0,155	76548,121	1,52
Base soporte.V.par:1	Aluminio, 6061-T6 (Ocurrencia)	2,279	840392,385	22,34
Cilindro soporte.V.par:1	Acero (Ocurrencia)	1,401	178831,585	13,73
Chaveta.V.par:1	Acero (Ocurrencia)	0,132	16800,000	1,29
Nanoposicionador.V.par:1	Aluminio, 1060 (Ocurrencia)	0,871	321048,212	8,53
PiezaInterna.V.par:1	Aluminio, 1060 (Ocurrencia)	0,159	58754,299	1,56
Portamuestras.V.par:1	Aluminio, 6061-T6 (Ocurrencia)	0,059	21685,239	0,58
Enganche4 aligerado.V.par:1	Aluminio, 6061-T6 (Ocurrencia)	0,386	142312,049	3,78

El programa también facilita las características de cada material del modelo:

Aluminio, 6061-T6

Tabla 3. Características aluminio 6061-T6. Fuente: SolidEdge

Propiedad	Valor
Densidad	2712,000 kg/m^3
Coeficiente de expansión térmica	0,000023 /C
Conductividad térmica	0,180 kW/m-C
Calor específico	920,000 J/kg-C
Módulo de elasticidad	68947,570 MPa
Coeficiente de Poisson	0,330
Límite elástico	275,790 MPa
Tensión de rotura	310,264 MPa

% de elongación	0,000

Acero

Tabla 4. Características acero. Fuente: SolidEdge

Propiedad	**Valor**
Densidad	7833,000 kg/m^3
Coeficiente de expansión térmica	0,000012 /C
Conductividad térmica	0,032 kW/m-C
Calor específico	481,000 J/kg-C
Módulo de elasticidad	199947,953 MPa
Coeficiente de Poisson	0,290
Límite elástico	262,001 MPa
Tensión de rotura	358,527 MPa
% de elongación	0,000

Aluminio, 1060

Tabla 5. Características aluminio 1060. Fuente: SolidEdge

Propiedad	**Valor**
Densidad	2712,000 kg/m^3
Coeficiente de expansión térmica	0,000023 /C
Conductividad térmica	0,221 kW/m-C
Calor específico	920,000 J/kg-C
Módulo de elasticidad	68947,570 MPa
Coeficiente de Poisson	0,330
Límite elástico	27,579 MPa
Tensión de rotura	68,948 MPa
% de elongación	0,000

Acero, estructural

Tabla 6. Características acero estructural. Fuente: SolidEdge

Propiedad	**Valor**
Densidad	2025,000 kg/m^3
Coeficiente de expansión térmica	0,000013 /C
Conductividad térmica	0,032 kW/m-C
Calor específico	481,000 J/kg-C
Módulo de elasticidad	199947,953 MPa
Coeficiente de Poisson	0,290
Límite elástico	262,001 MPa
Tensión de rotura	358,527 MPa
% de elongación	0,000

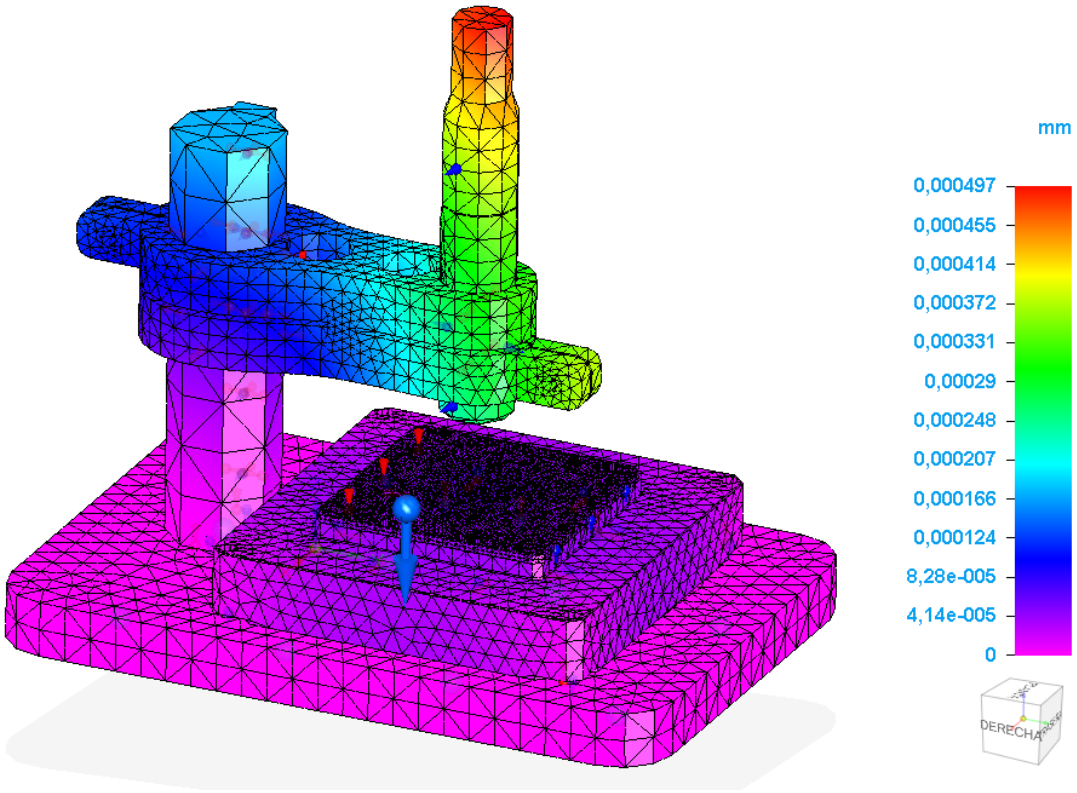
Por último, se observan las características del mallado:

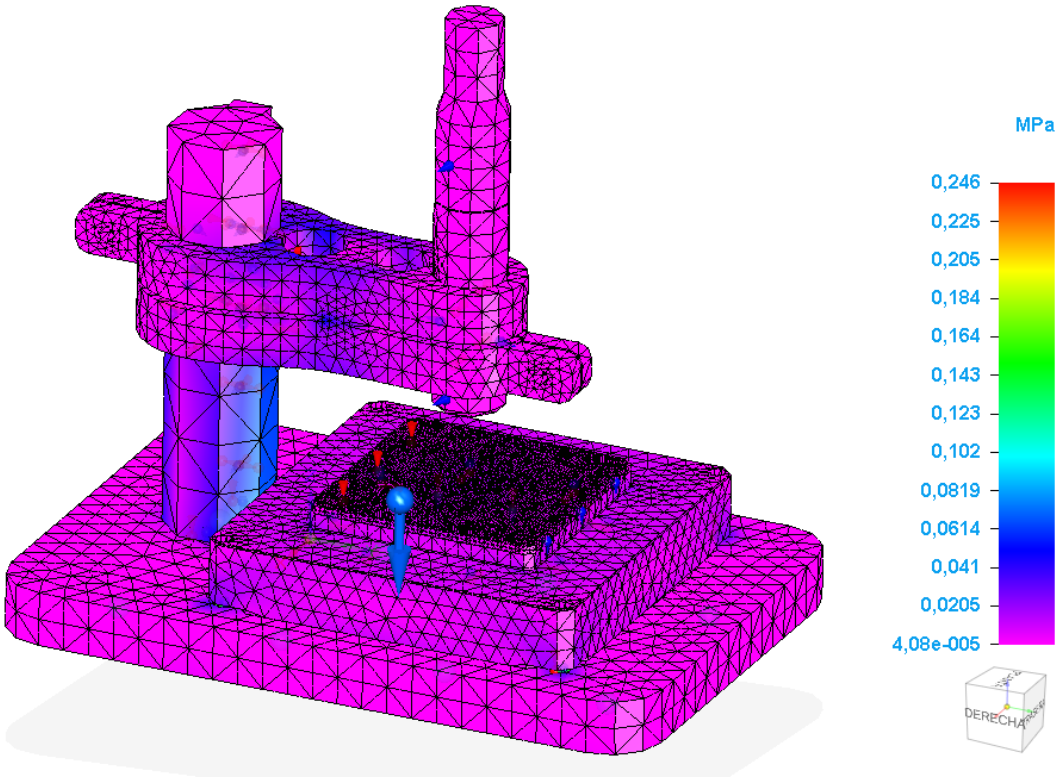
Tabla 7. Características mallado. Fuente: SolidEdge

Tipo de mallado	**Tetraédrico**

Número total de cuerpos mallados	8
Número total de elementos	172.952
Número total de nodos	275.213
Tamaño subjetivo de malla (1-10)	1

A continuación, se observan los resultados del desplazamiento y tensión del conjunto:




MPa
0,246
0,225
0,205
0,184
0,164
0,143
0,123
0,102
0,0819
0,0614
0,041
0,0205
4,08e-005
DERECHA

2.2.Informe sensor táctil Heidenhain

La única carga impuesta fue la de la gravedad:

Tabla 8. Carga impuesta en el conjunto sensor táctil

Nombre de carga	Tipo de carga	Valor de carga	Distribución de carga	Dirección de carga	Opción de dirección de carga
Gravedad 1	Gravedad	981 cm/s^2		(0,00, 0,00, -1,00)	A lo largo del vector

A continuación, se observan las características de cada componente del conjunto. Estas fueron impuestas en el momento del diseño de cada componente:

Tabla 9. Características componentes sensor táctil. Fuente: SolidEdge

Nombre del sólido	Material	Masa	Volumen	Peso
posicionadora 50Ac50Al.par:1	Aluminio, 2024-T4 (Ocurrencia)	1,794 kg	648443,016 mm^3	17,58 N
Base soporte.V.par:1	Aluminio, 1060 (Ocurrencia)	2,279 kg	840392,385 mm^3	22,34 N
Cilindro soporte.V.par:1	Acero (Ocurrencia)	1,401 kg	178831,585 mm^3	13,73 N
Chaveta.V.par:1	Acero (Ocurrencia)	0,132 kg	16800,000 mm^3	1,29 N
enganche heidenhain.par:1	Aluminio, 6061-T6 (Ocurrencia)	0,135 kg	49679,349 mm^3	1,32 N
Sensor Heidenhain simple.par:1	Acero inoxidable, 420 (Ocurrencia)	0,180 kg	39502,102 mm^3	1,76 N

El programa también facilita las características de cada material del modelo:

Aluminio, 1060

Tabla 10. Características aluminio 1060. Fuente: SolidEdge

Propiedad	Valor
Densidad	2712,000 kg/m^3
Coeficiente de expansión térmica	0,000023 /C
Conductividad térmica	0,221 kW/m-C
Calor específico	920,000 J/kg-C
Módulo de elasticidad	68947,570 MPa
Coeficiente de Poisson	0,330
Límite elástico	27,579 MPa
Tensión de rotura	68,948 MPa
% de elongación	0,000

Acero

Tabla 11. Características acero. Fuente: SolidEdge

Propiedad	**Valor**
Densidad	7833,000 kg/m^3
Coeficiente de expansión térmica	0,000012 /C
Conductividad térmica	0,032 kW/m-C
Calor específico	481,000 J/kg-C
Módulo de elasticidad	199947,953 MPa
Coeficiente de Poisson	0,290
Límite elástico	262,001 MPa
Tensión de rotura	358,527 MPa
% de elongación	0,000

Aluminio, 6061-T6

Tabla 12. Características aluminio 6061-T6. Fuente: SolidEdge.

Propiedad	**Valor**
Densidad	2712,000 kg/m^3
Coeficiente de expansión térmica	0,000023 /C
Conductividad térmica	0,180 kW/m-C
Calor específico	920,000 J/kg-C
Módulo de elasticidad	68947,570 MPa
Coeficiente de Poisson	0,330
Límite elástico	275,790 MPa
Tensión de rotura	310,264 MPa
% de elongación	0,000

Acero inoxidable, 420

Tabla 13. Características acero inoxidable 420. Fuente: SolidEdge.

Propiedad	**Valor**
Densidad	4556,700 kg/m^3
Coeficiente de expansión térmica	0,000010 /C
Conductividad térmica	0,025 kW/m-C
Calor específico	502,000 J/kg-C
Módulo de elasticidad	199947,953 MPa
Coeficiente de Poisson	0,290
Límite elástico	344,738 MPa
Tensión de rotura	655,002 MPa
% de elongación	0,000

Aluminio, 2024-T4

Tabla 14. Características aluminio 2024-T4. Fuente: SolidEdge

Propiedad	**Valor**
Densidad	2767,000 kg/m^3
Coeficiente de expansión térmica	0,001225 /C
Conductividad térmica	0,189 kW/m-C
Calor específico	920,000 J/kg-C
Módulo de elasticidad	73084,424 MPa
Coeficiente de Poisson	0,330
Límite elástico	289,580 MPa
Tensión de rotura	427,475 MPa
% de elongación	0,000

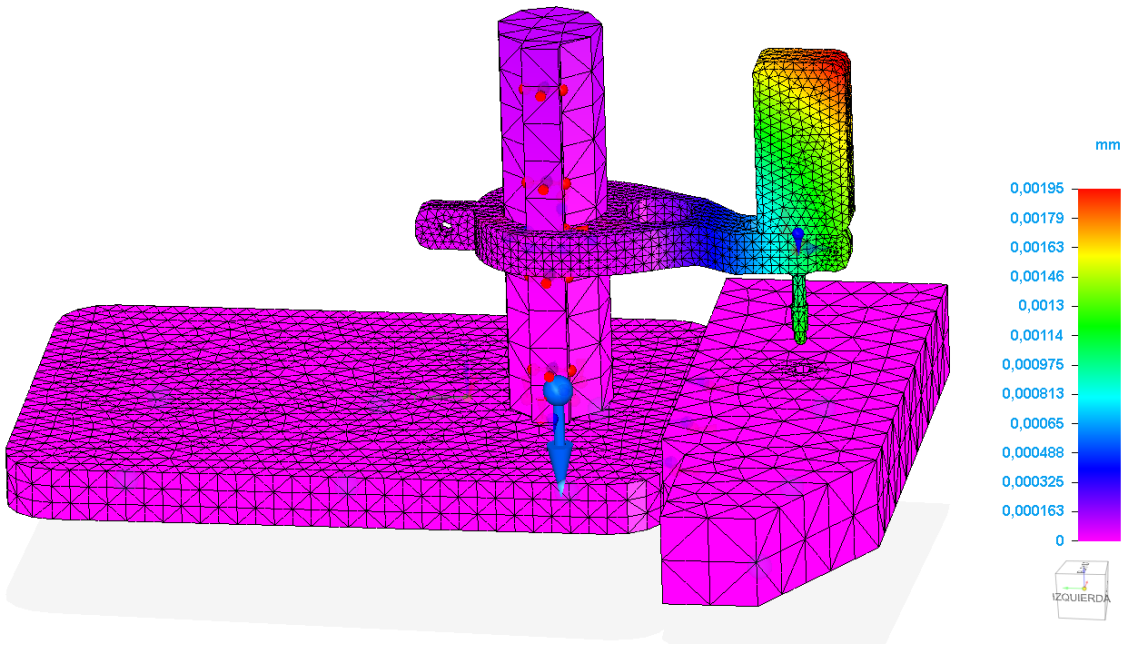
Por último, se observan las características del mallado:

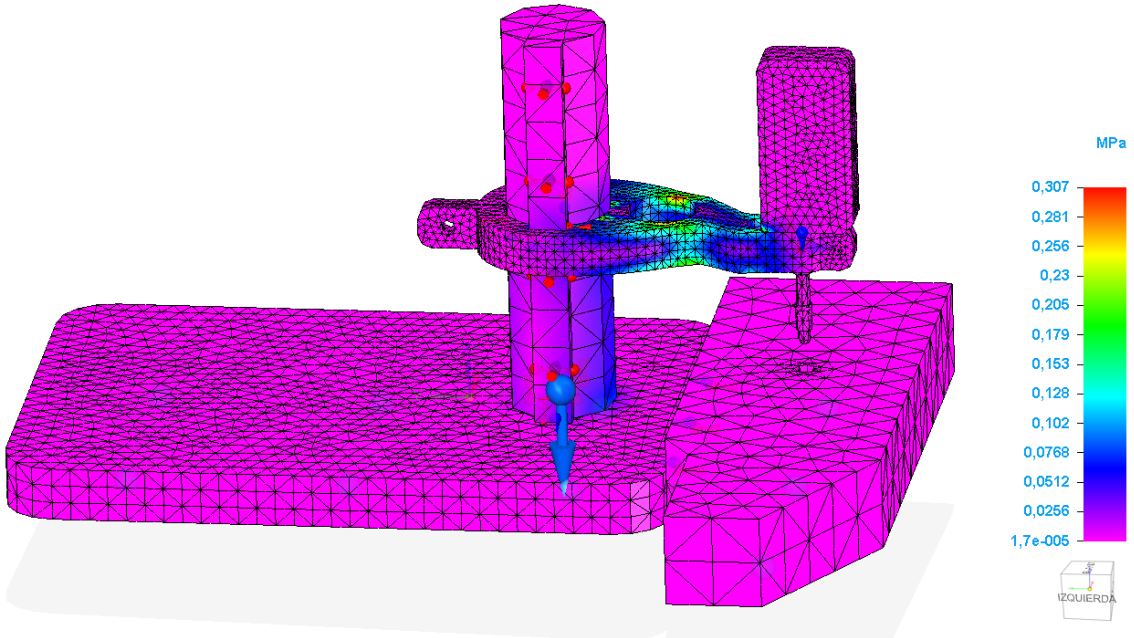
Información de mallado

Tabla 15. Características mallado. Fuente: SolidEdge

Tipo de mallado	**Tetraédrico**
Número total de cuerpos mallados	6
Número total de elementos	47.174
Número total de nodos	75.494
Tamaño subjetivo de malla (1-10)	2

A continuación, se observan los resultados del desplazamiento y tensión del conjunto:





3. Estudios de expansión térmica

3.1.Estudio conjunto sensor confocal

Muestra [mm]	ΔLx [mm]	X
0	-0,000239998	20
1	-0,000215998	21
2	-0,000191998	22
3	-0,000167998	23
4	-0,000143998	24
5	-0,000119998	25
6	-0,000095998	26
7	-7,1998E-05	27
8	-4,7998E-05	28
9	-0,000023998	29
10	2E-09	30
11	2,4002E-05	31
12	0,000048002	32
13	7,2002E-05	33
14	9,6002E-05	34
15	0,000120002	35
16	0,000144002	36
17	0,000168002	37
18	0,000192002	38
19	0,000216002	39
20	0,000240002	40
21	0,000264002	41
22	0,000288002	42
23	0,000312002	43
24	0,000336002	44
25	0,000360002	45
26	0,000384002	46
27	0,000408002	47
28	0,000432002	48
29	0,000456002	49
30	0,000480002	50

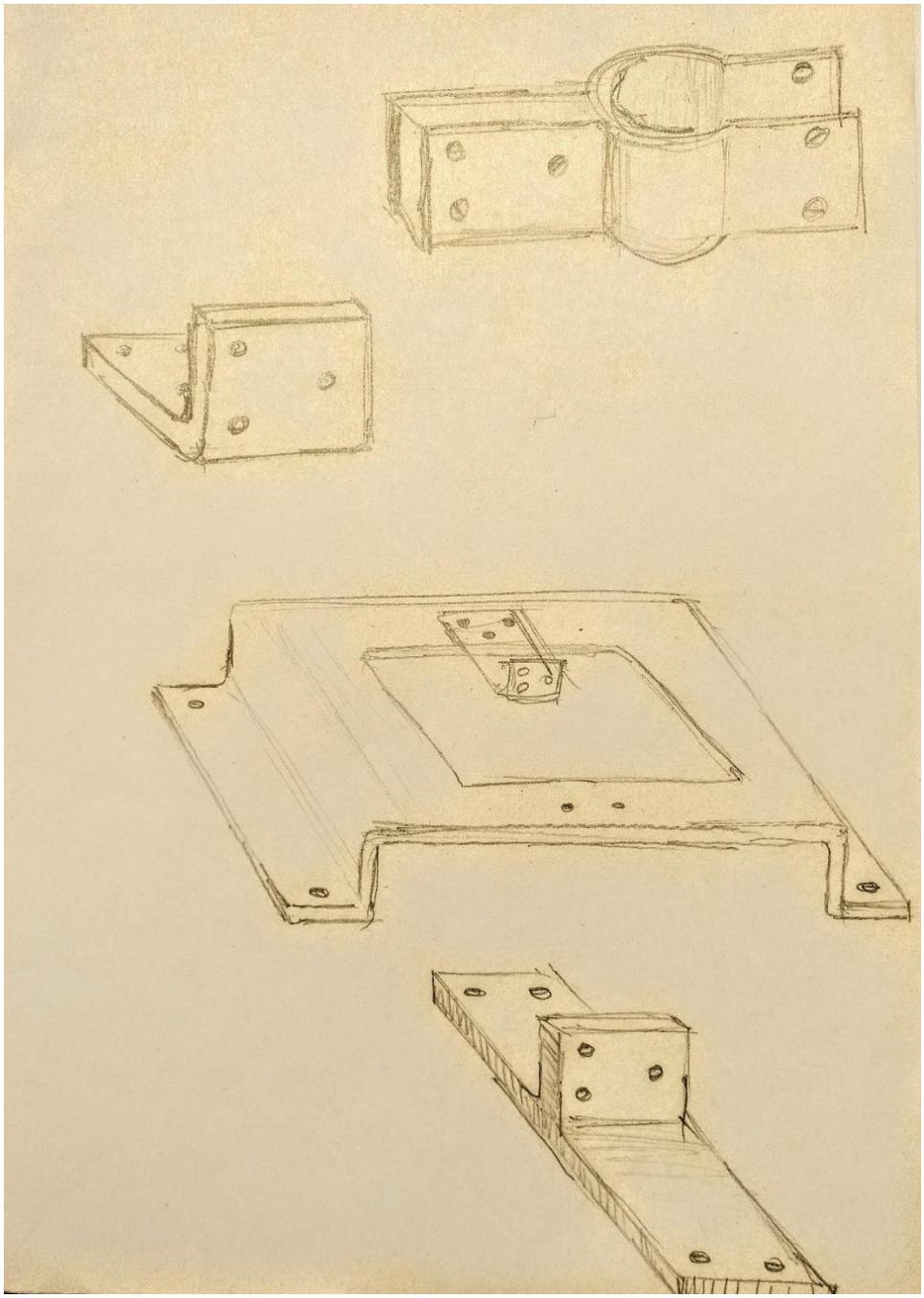
Fuente: elaboración propia mediante Excel

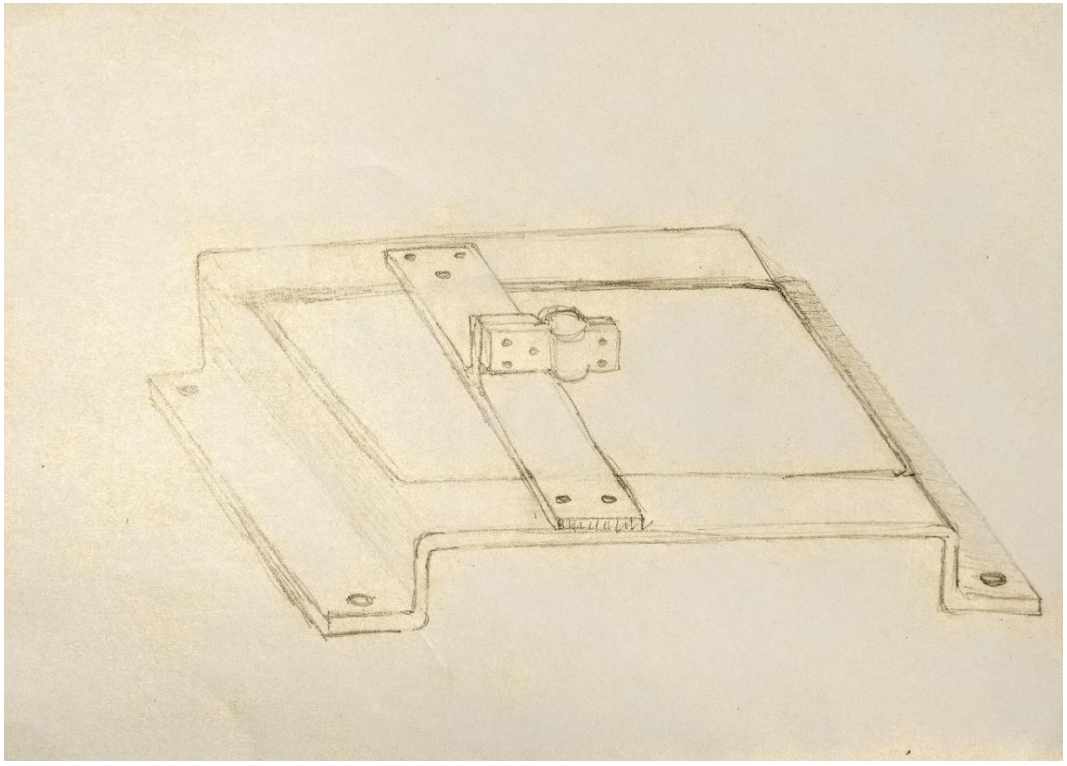
3.2.Estudio conjunto sensor táctil

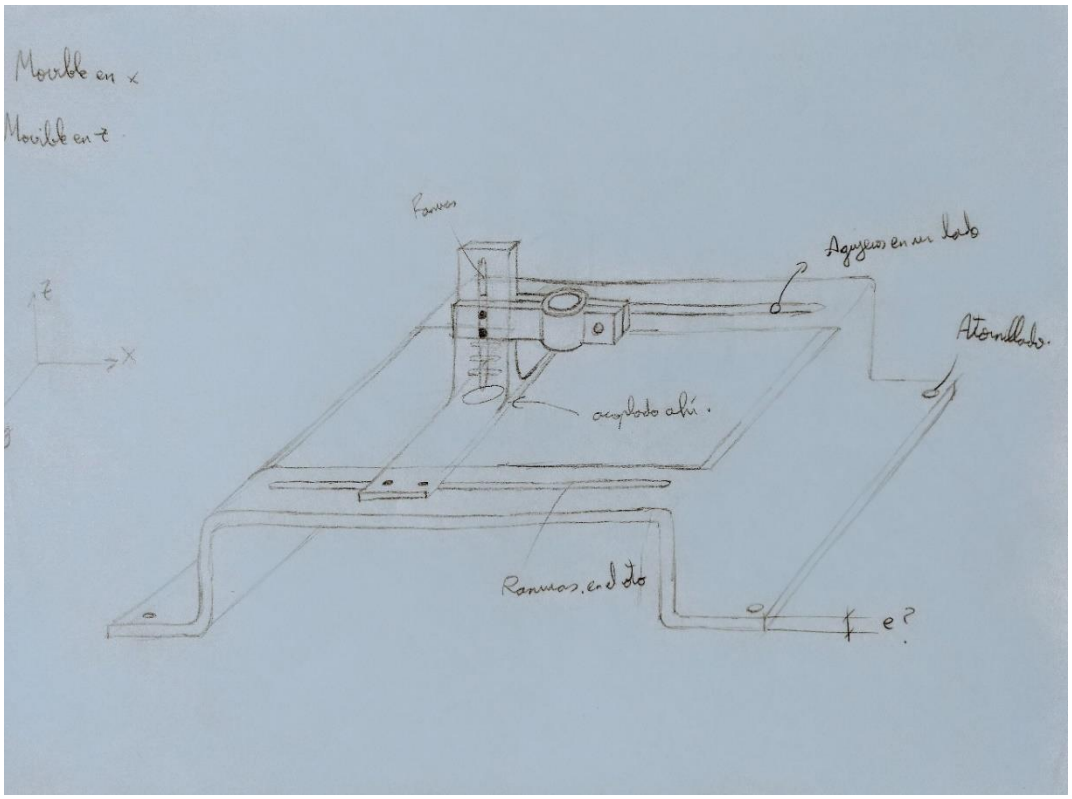
Muestra [mm]	ΔLx [mm]
0	-0,000239998
1	-0,000215998
2	-0,000191998
3	-0,000167998
4	-0,000143998
5	-0,000119998
6	-9,5998E-05
7	-7,1998E-05
8	-4,7998E-05
9	-2,3998E-05
10	2E-09
11	0,000024002
12	4,8002E-05
13	7,2002E-05
14	0,000096002
15	0,000120002
16	0,000144002
17	0,000168002
18	0,000192002
19	0,000216002
20	0,000240002
21	0,000264002
22	0,000288002
23	0,000312002
24	0,000336002
25	0,000360002
26	0,000384002
27	0,000408002
28	0,000432002
29	0,000456002
30	0,000480002

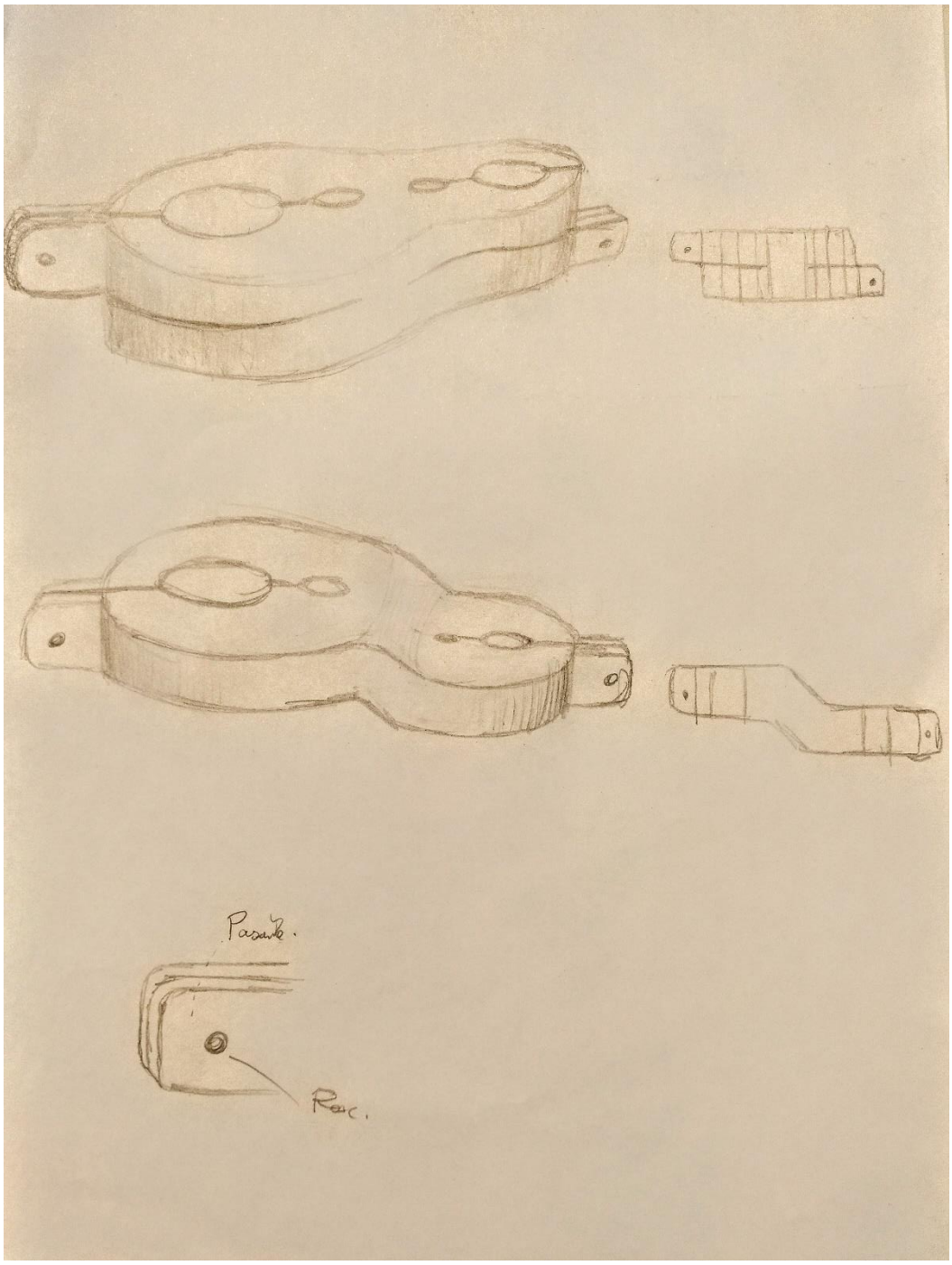
Fuente: elaboración propia mediante Excel

4. Bocetos





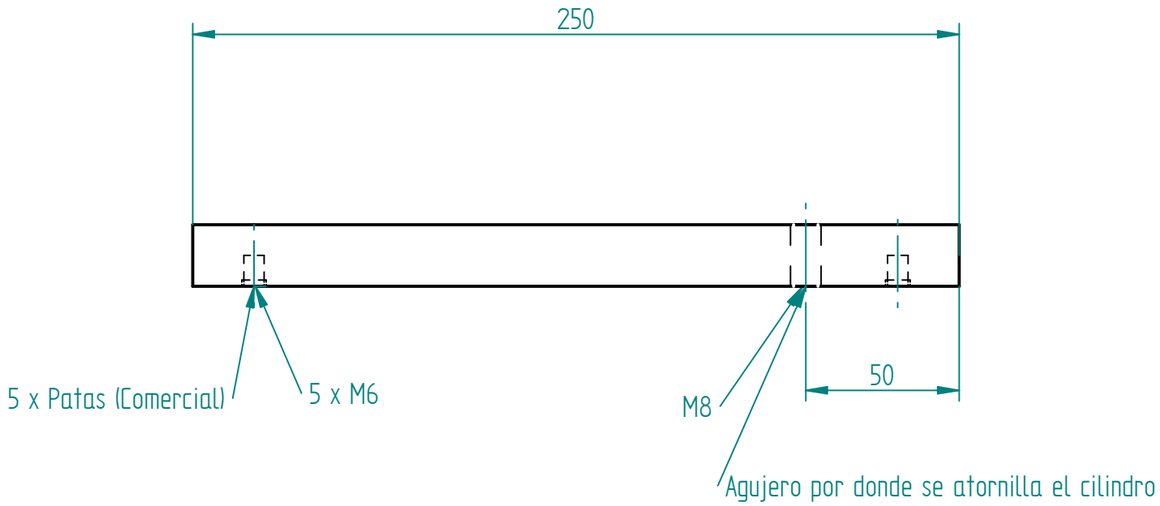

Movible en x
Movible en z
Ranuras
Agujeros en un lado
Atornillado.
z
x
acoplado ahí.
Ranuras en el lado
e?

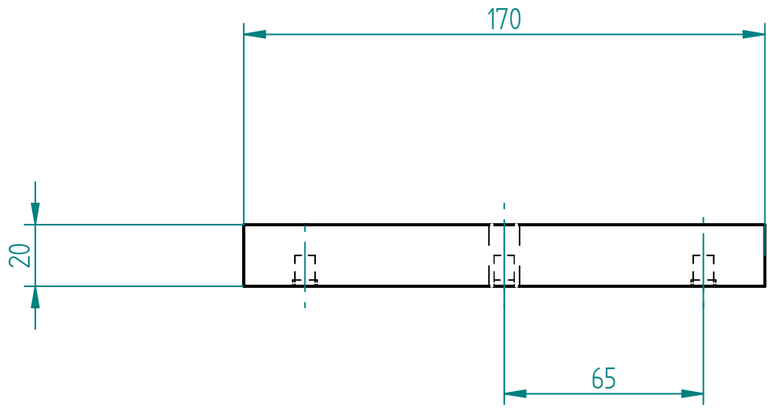


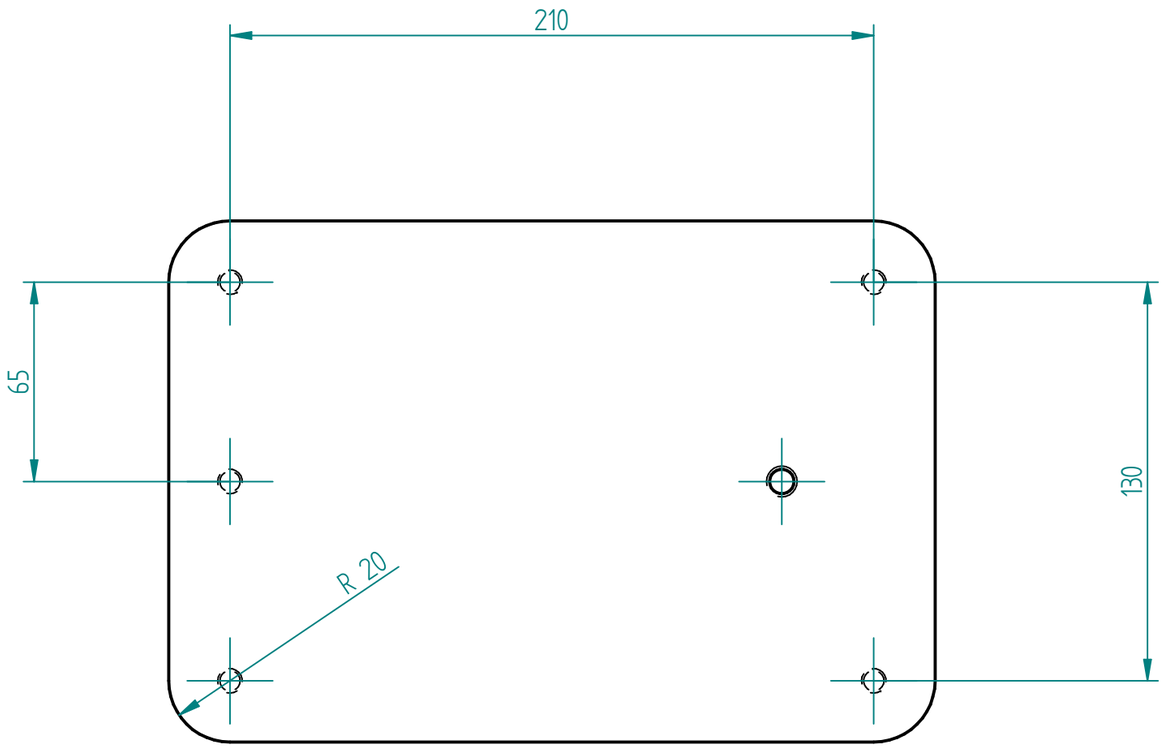
Fuente: elaboración propia

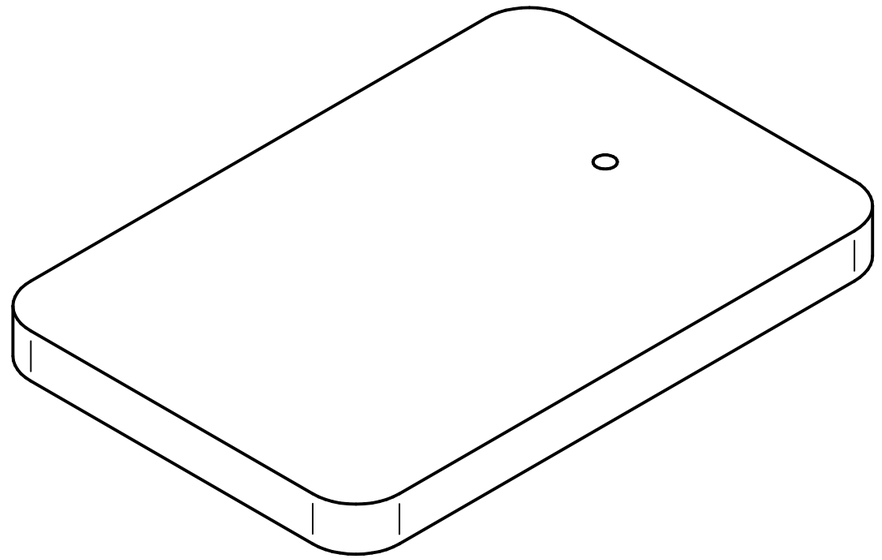
5. Planos

Revisiones			
Rev	Descripción	Fecha	Aprobado









Duraluminio 6082 – Anodizado blanco

	Nombre	Fecha
Dibujado	Javier Camino	23/06/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

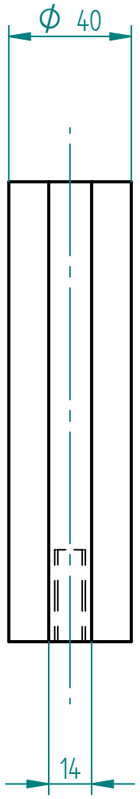
Título: Base soporte

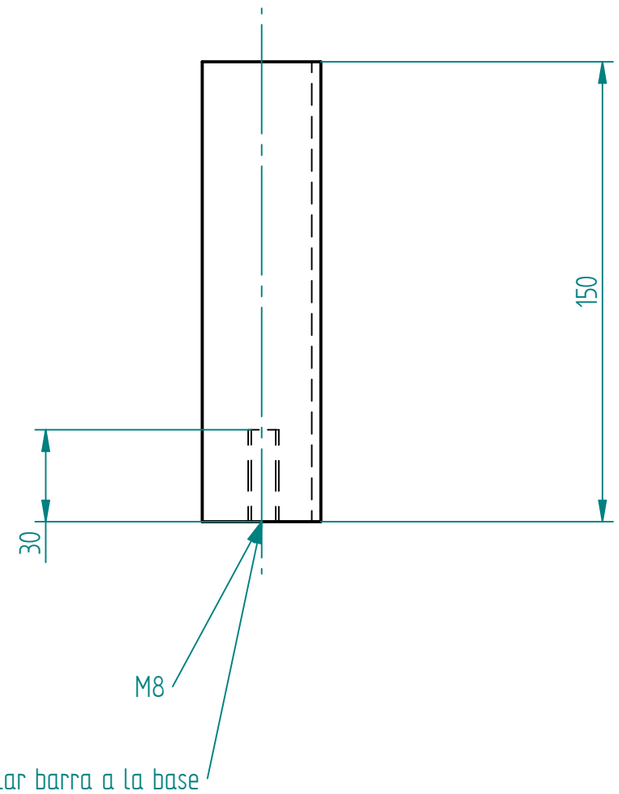
A3	Plano 1	Rev

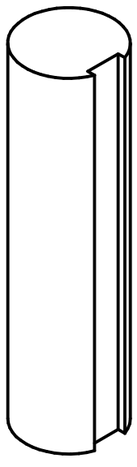
Archivo: Base soporte.V.dft

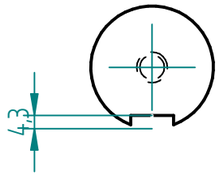
Escala 1:2	Peso 2,279 kg.	Hoja 1 de 1

Revisiones			
Rev	Descripción	Fecha	Aprobado









Acero niquelado - F-118 - F-114

	Nombre	Fecha
Dibujado	Javier Camino	22/06/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

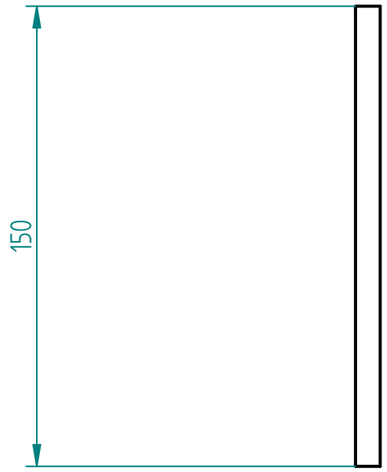
Título: Cilindro soporte

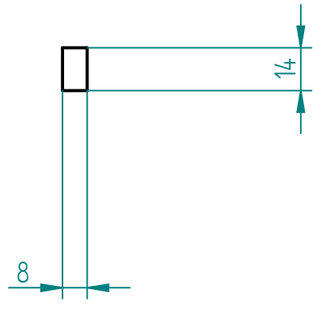
A3 | Plano 2 | Rev

Archivo: Cilindro soporte.V.dft

Escala 1:2 | Peso 1,389 kg. | Hoja 1 de 1

Revisiones			
Rev	Descripción	Fecha	Aprobado





Acero niquelado - F-114

	Nombre	Fecha
Dibujado	Javier Camino	19/05/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

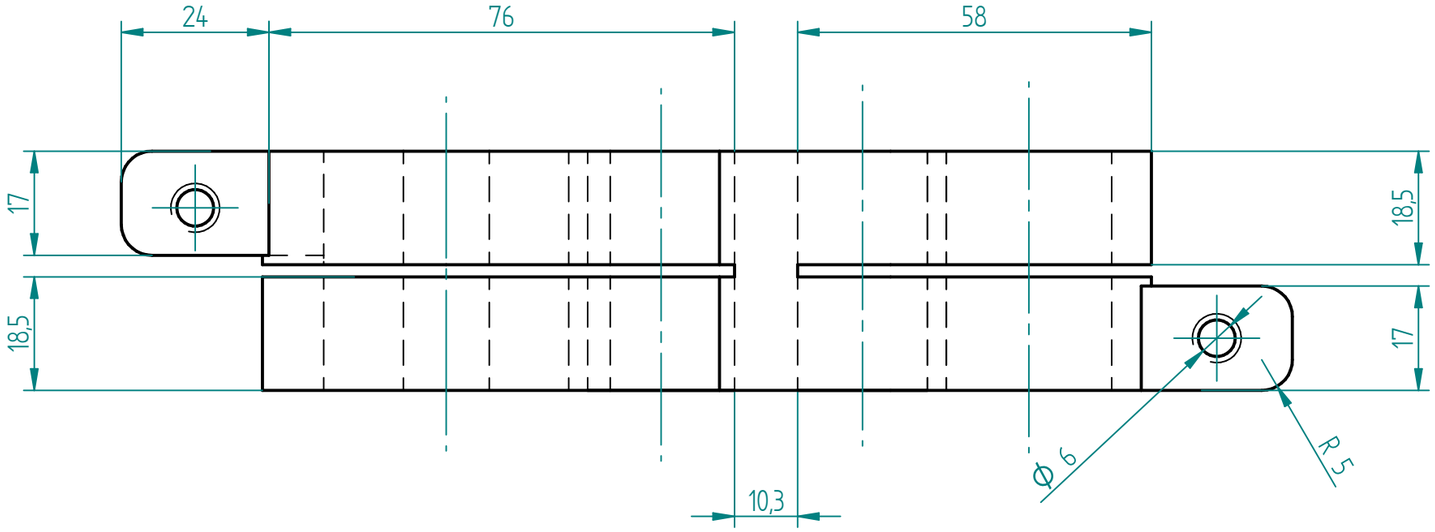
Título: Chaveta

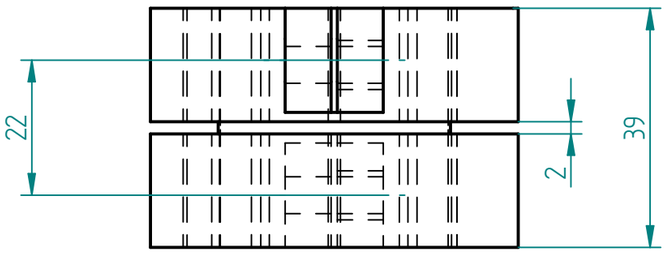
A3 | Plano 3 | Rev

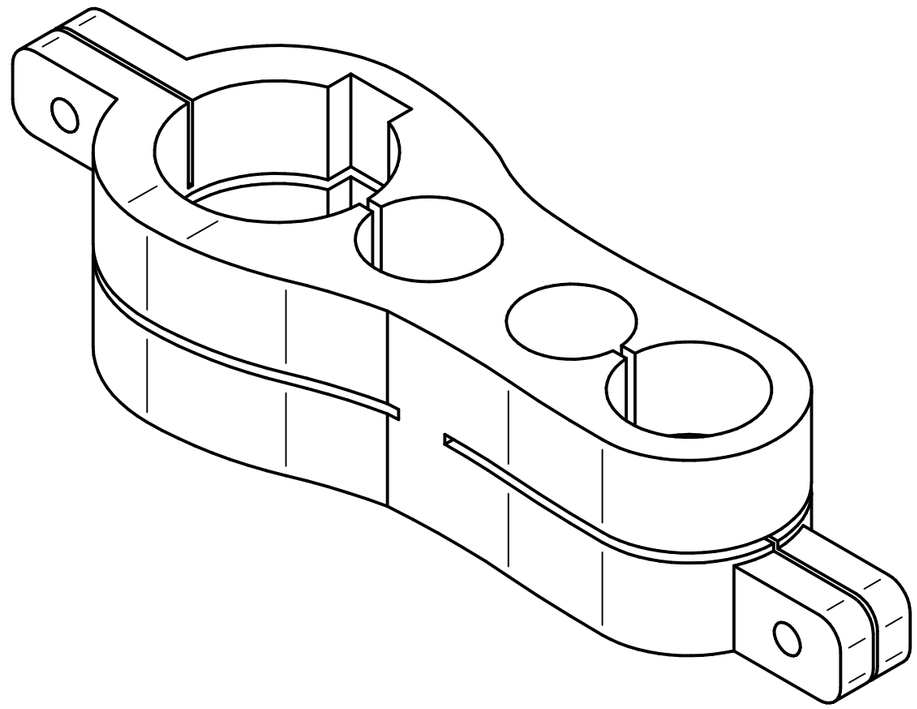
Archivo: Chaveta.V.dft

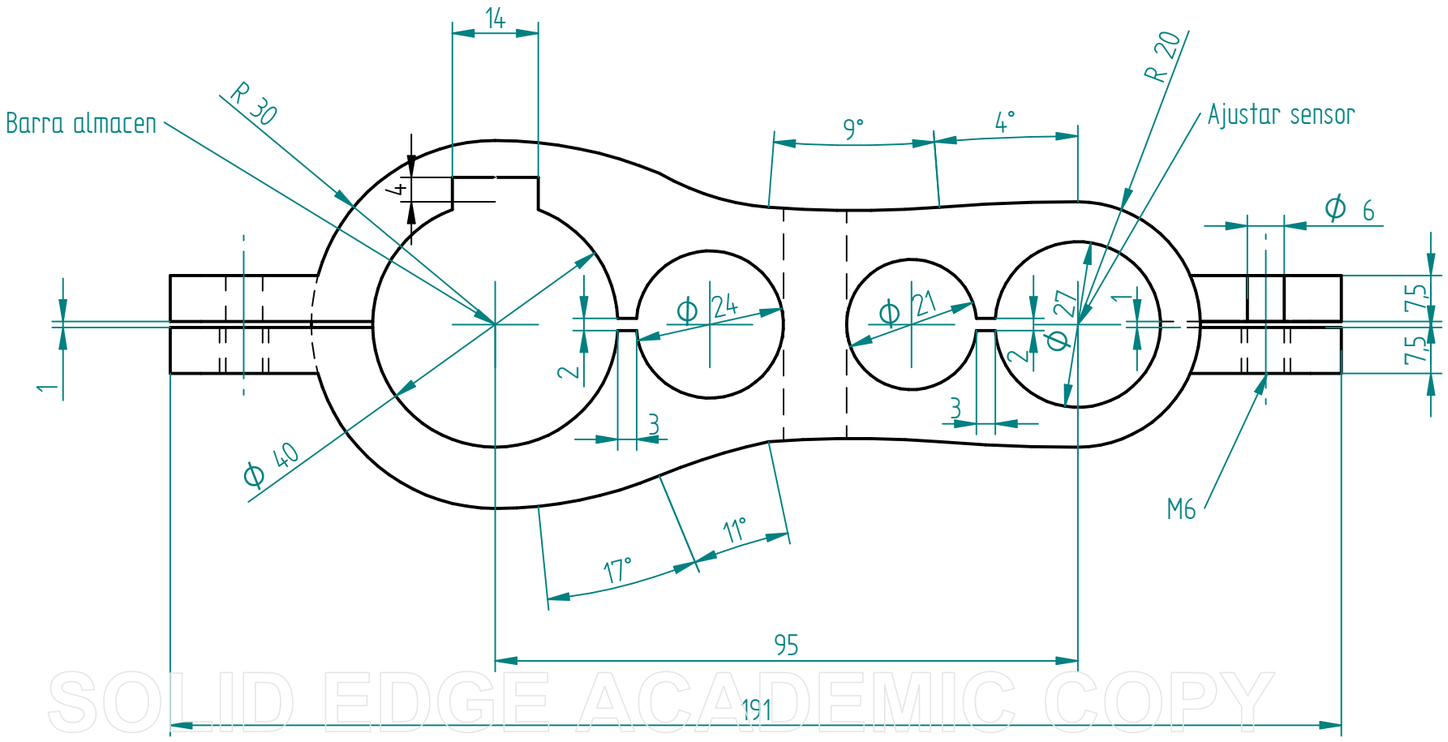
Escala 1:2 | Peso 0,132 kg. | Hoja 1 de 1

Revisiones			
Rev	Descripción	Fecha	Aprobado









Duraluminio 6082 – Anodizado blanco

	Nombre	Fecha
Dibujado	Javier Camino	22/06/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

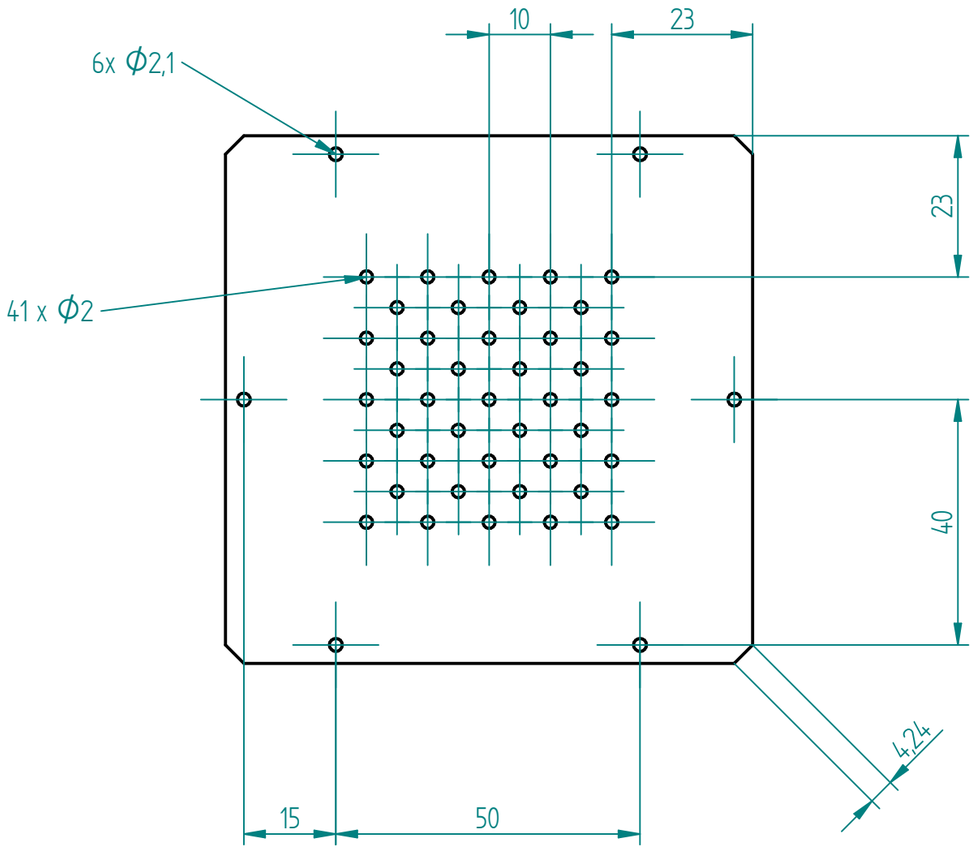
Título: Enganche sensor

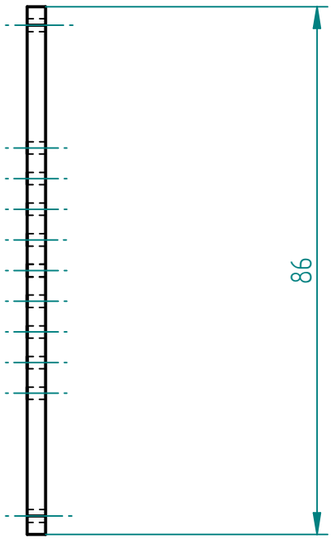
A3	Plano 4	Rev

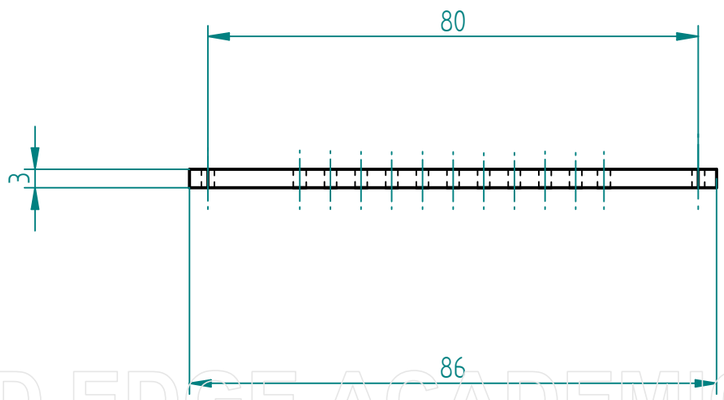
Archivo: Enganche4 aligerado.V.dft

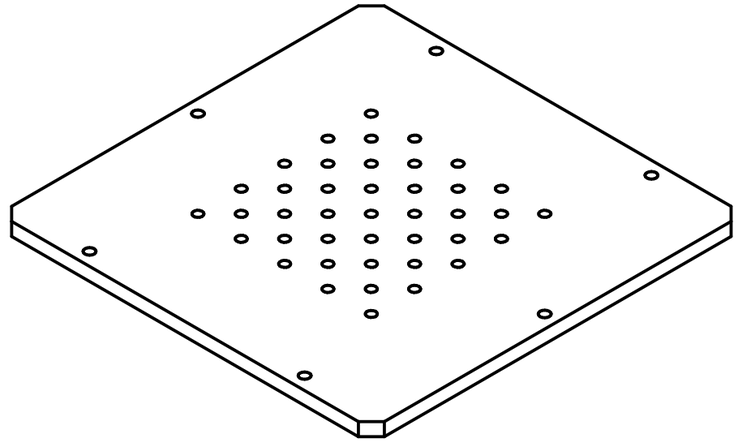
Escala 1:1	Peso 0,386 kg.	Hoja 1 de 1

Revisiones			
Rev	Descripción	Fecha	Aprobado









Duraluminio 6082 – Anodizado blanco

	Nombre	Fecha
Dibujado	Javier Camino	23/06/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

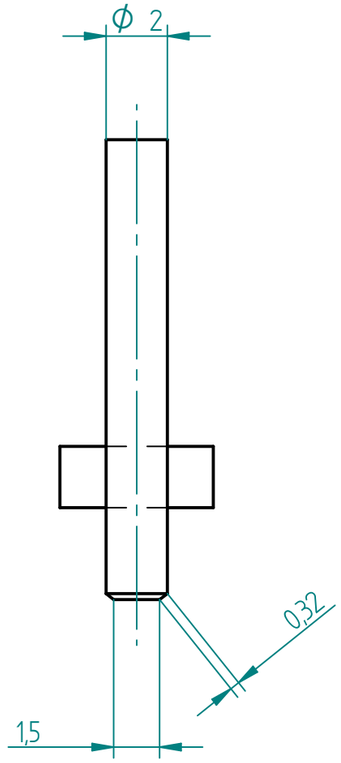
Título: Portamuestras

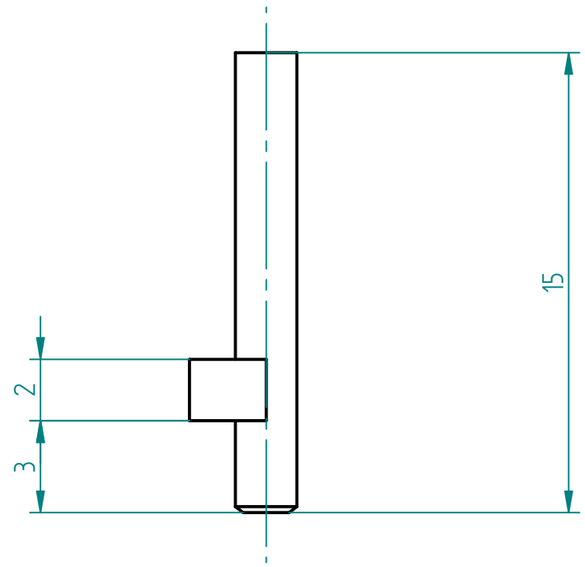
A3 | Plano 5 | Rev

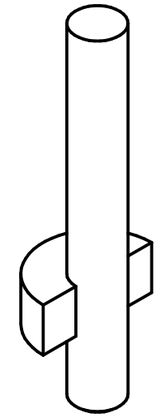
Archivo: Portamuestras.V.dft

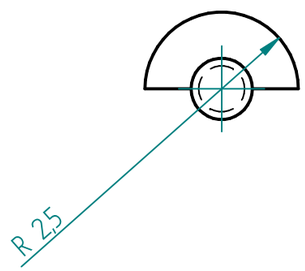
Escala 1:1 | Peso 0,059 kg. | Hoja 1 de 1

Revisiones			
Rev	Descripción	Fecha	Aprobado









Varillas (x5) Latón

	Nombre	Fecha
Dibujado	Javier Camino	23/06/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

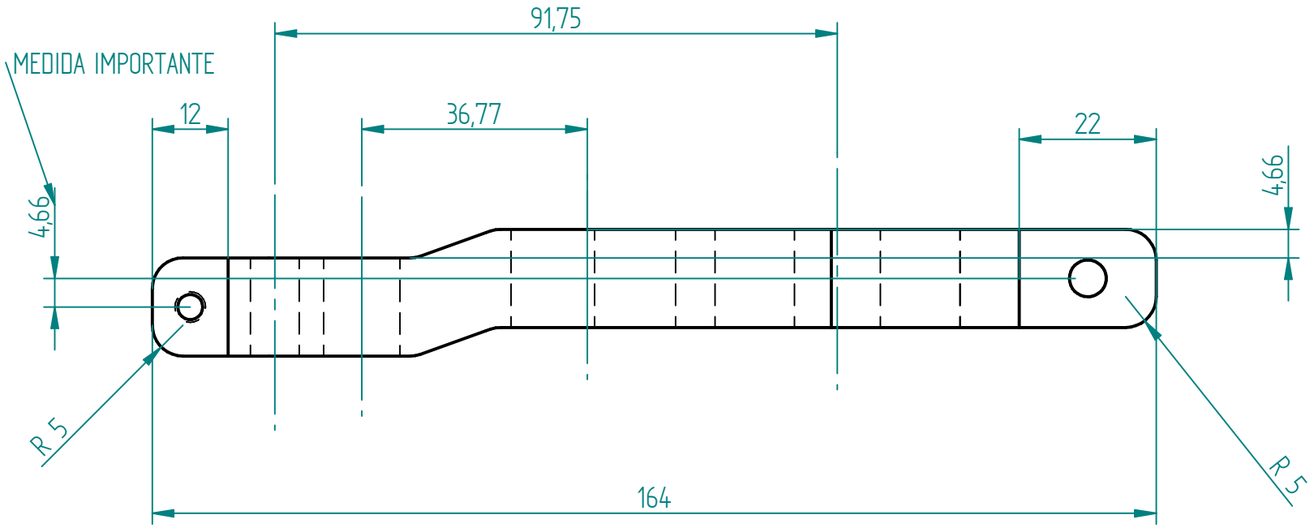
Título: Varilla

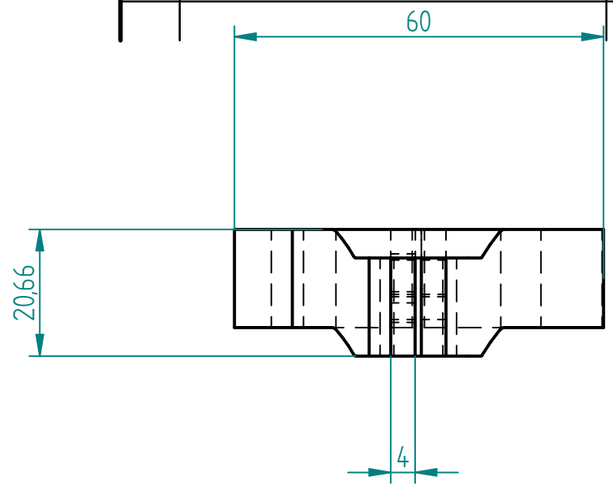
A3 | Plano 6 | Rev

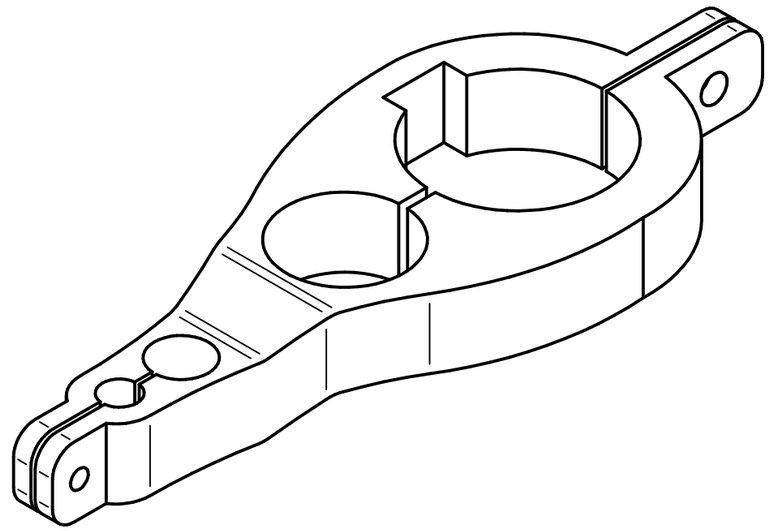
Archivo: Varilla.V.dft

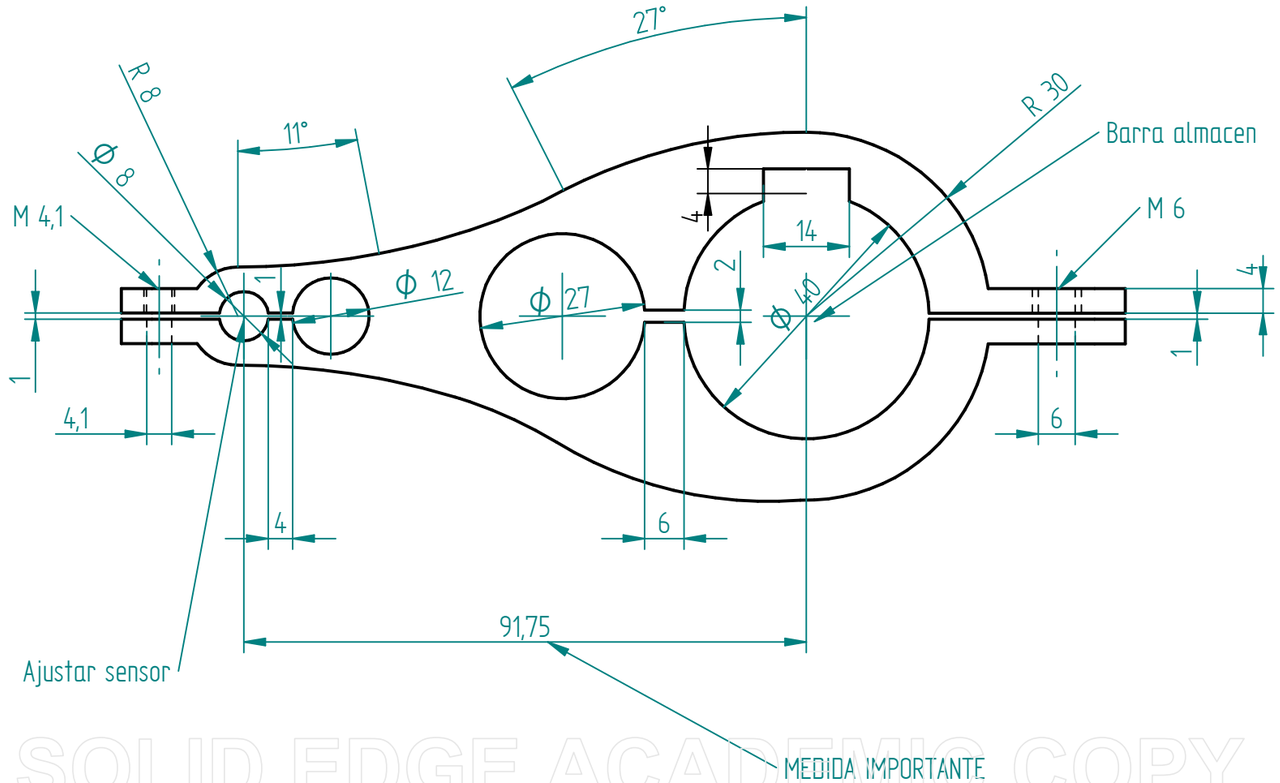
Escala 5:1 | Peso 0,01 kg. | Hoja 1 de 1

Revisiones			
Rev	Descripción	Fecha	Aprobado









Duraluminio 6082 – Anodizado blanco

	Nombre	Fecha
Dibujado	Javier Camino	23/07/18
Comprobado		
Aprobado 1		
Aprobado 2		

Salvo indicación contraria
cotas en milímetros
ángulos en grados
tolerancias ±0,5 y ±1°

Solid Edge ST
Siemens PLM Software

Título: Enganche Heidenhain

A3 | Plano 7 | Rev

Archivo: enganche heidenhain.dft

Escala 1:1 | Peso 0,135 kg. | Hoja 1 de 1