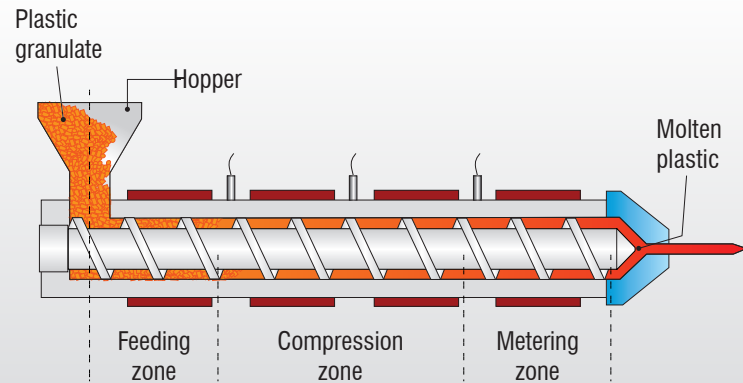


Sensor system for precise color measurement under pressure in the extruder



Precise color detection for 100% inline process monitoring

When processing solid to highly viscous materials such as gelatin, syrup, or plastics, the material is continuously compacted in an extruder and discharged as an extrudate under high pressure.

Precise temperature control is crucial during the extrusion process. If the material is heated too much, it can suffer thermal damage, which can lead to unwanted discoloration or burning. To detect such process deviations early on, the color of the material is monitored directly in the extruder at specific measurement points. Depending on the material properties, the measurement is performed either using the transmission method (for transparent media such as gelatin) or the reflection method (for opaque materials such as plastics).

The CFS3 (transmission) or CFS4 (reflection) sensors are used for this inline measurement task. The sensors are integrated directly into the extruder and are available with ½"-20 UNF or M12 threads, as well as in various models. This makes them suitable for demanding process conditions with pressures of up to 2,400 bar and temperatures of up to 500 °C. Color measurement is performed directly on the inner wall of the extruder. The measurement data collected is used for process control. This makes it possible to detect thermal overloads, burns, and contamination early on and take corrective action before scrap is produced.

The smart and precise color sensors in Micro-Epsilon's colorSENSOR CFO series are characterized by high color accuracy, excellent repeatability, and fast measurement acquisition. Even the slightest color variations are reliably detected, allowing for immediate action during the production process. Up to 320 colors can be programmed into 254 color groups. Configuration is easily performed via an intuitive, web-based user interface. This attractive sensor system for precise color measurement in the extruder consists of the CFO250 controller, one of the available sensors CFS4-T250-P200, CFS4-BOA-T400-P2400, CFS3-T250-P200, CFS3-BOA-T400-P2400, or CFS4-S-E-T250, and a cable set for power supply, connection to a PLC, or use of the digital I/Os.

This system combination offers high measurement accuracy, a robust design for industrial use, and an excellent price-performance ratio.

Requirements for the measurement system

- Inline color measurement
- Pressure resistance < 2400 bar
- Repeatability $\Delta E < 0.3$
- Temperature resistance < 500°C

Ambient conditions

- The mass is continuously compressed (< 2400 bar)
- Hot material in the form of extrudate (< 500°C)

System design

Controller:

- colorSENSOR CFO250

One of the sensors:

- Reflex sensor: CFS4-T250-P200 (20UNF)
- Reflex sensor: CFS4-BOA-T400-P2400 (20UNF)
- Transmission sensor: CFS3-T250-P200 (20UNF)
- Transmission sensor: CFS3-BOA-T400-P2400 (20UNF)
- Reflex sensor: CFS4-S-E-T250 (M12)

Cable set:

- Power supply, PLC connection, or digital I/Os

Advantages

- Sensors directly in the extruder with ½"-20UNF or M12 fit
- Pressure-resistant < 2400 bar
- Temperature-resistant < 500 °C
- High repeatability $\Delta E < 0.3$
- Multi-teach function and formation of color groups
- Modern, user-friendly web interface
- High color accuracy
- Simple and fast integration of the system in existing plants

Model	CFS4-T250-P200	CFS4-BOA-T400-P2400	CFS3-T250-P200	CFS3-BOA-T400-P2400	CFS4-S-E-T250
Sensor type	Reflection		Transmission		Reflection
Working distance ^[1]	0 mm (internally 5 mm)		0 mm (internally 5 mm)		0 mm (internally 5 mm)
Measurement spot diameter ^[1]	10 mm		2.5 mm		10 mm
Light spot diameter ^[1]	12 mm		12 mm		12 mm
Measurement geometry	0°:0°		0°:180°		0°:0°
Min. target size (flat)	Ø 10 mm		Ø 2.5 mm		Ø 10 mm
Minimum curvature radius of target (curved)	100 mm		25 mm		100 mm
Sensitivity	Distance ^{[1] [2]}	< 10.4 ΔE / mm	< 0.3 ΔE / mm		< 10.4 ΔE / mm
	Tilt ^{[1] [2]}	< 0.3 ΔE / °	< 0.3 ΔE / °		< 0.3 ΔE / °
	Ambient light ^{[1] [2]}	< 0.3 ΔE / 1,000 lx	< 0.3 ΔE / 1,000 lx		< 0.3 ΔE / 1,000 lx
Permissible ambient light ^{[1] [2]}	< 40,000 lx		< 40,000 lx		< 40,000 lx
Max. tilt angle ^{[1] [2]}	±45°		±30°		±45°
Pressure resistance of sensor head	< 200 bar	< 2400 bar	< 200 bar	< 2400 bar	< 0.5 bar
Connection	integrated fiber-optic cable (axial) with metal-silicone (T) sheath, standard length 1.2 m; other lengths 0.3 ... 2.4 m optionally available	integrated fiber-optic cable (axial) with corrugated ring hose and steel braid (BOA) sheath, standard length 1.2 m; other lengths 0.3 ... 2.4 m optionally available	integrated fiber-optic cable (axial) with metal-silicone (T) sheath, standard length 1.2 m; other lengths 0.3 ... 2.4 m optionally available	integrated fiber-optic cable (axial) with corrugated ring hose and steel braid (BOA) sheath, standard length 1.2 m; other lengths 0.3 ... 2.4 m optionally available	integrated fiber-optic cable (axial) with metal with special bonding (E) sheath, standard length 1.2 m; other lengths 0.3 ... 2.4 m optionally available
Mounting ^[3]	FA (M18x1)		FA (M18x1)		FA (M18x1)
Temperature range ^[4]	Storage / Operation	Sensor: -40 ... +250 °C; Cable: -60 ... +180 °C	Sensor: -40 ... +250 °C; Cable: -60 ... +180 °C	Sensor: -40 ... +400 °C; Cable: -60 ... +600 °C	Sensor: -40 ... +250 °C; Cable: -60 ... +180 °C
Air humidity	20 ... 80 % RH (non-condensing)		20 ... 80 % RH (non-condensing)		20 ... 80 % RH (non-condensing)
Protection class (DIN EN 60529)	IP64		IP64		IP40
Material	Stainless steel, fiberglass bundle with metal-silicone sheath (T)	Stainless steel, fiberglass bundle with corrugated ring hose and steel braid (BOA)	Stainless steel, fiberglass bundle with metal-silicone sheath (T)	Stainless steel, fiberglass bundle with corrugated ring hose and steel braid (BOA)	Stainless steel, fiberglass bundle with metal with special bonding (E)
Weight	110 g		200 g		90 g

The specified data apply to a white, diffuse reflecting surface (Zenith white reference)

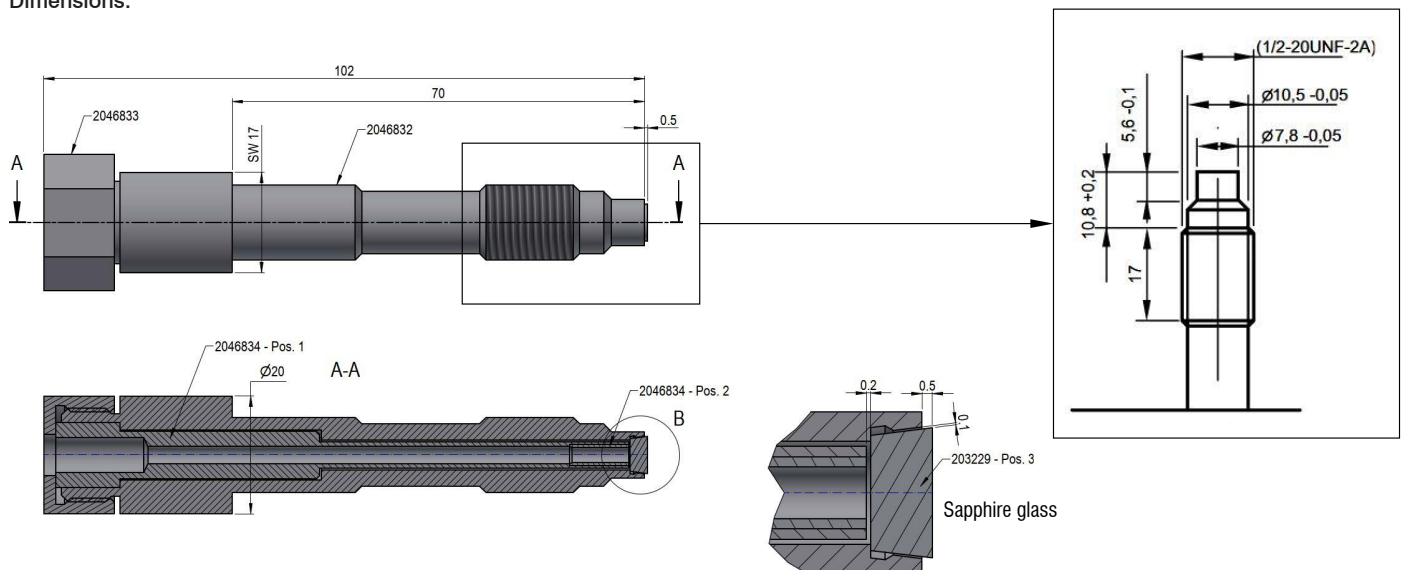
^[1] When used with the colorSENSOR CFO250 and a repeatability of $\Delta E \leq 0.3$

^[2] Valid for the optimal working distance

^[3] The sleeve must be tightened to a torque of 35 Nm

^[4] Sensors rated up to 500 °C available upon request

Dimensions:



CFS3 or CFS4-S-T250 for 108256851 protective sleeve

Dimensions in mm, not to scale.

Model		CFO250
Article number		10235603
No. of measurement channels		1
Repeatability ^[1]		$\Delta E \leq 0.3$
Color distance		$\Delta E \leq 0.6$
Spectral range		400 ... 680 nm
Color spaces		XYZ, xyZ, L*a*b, L*u*v, u'v'L*, L*C*h°
Illuminants		D65
Standard observer		10°
Tolerance		Classify model; Sphere (ΔE); Cylinder (ΔL , Δa , Δb); Box (ΔL , Δa , Δb); Segment tolerance
Memory		Max. 320 colors in non-volatile EEPROM with parameter sets
Measuring rate		Standard 1 kHz; max. 30 kHz
Output of measurement values		Lab, XYZ max. 500 Hz via UDP and USB max. 380 Hz via RS232 max. 20 Hz via REST API max. 5 Hz via Modbus
Temperature stability		< 0.1% FSO / K ^[2]
Light source		White light LED (425 ... 750 nm); AC operation (adjustable or OFF for self-illuminator switchable via software)
Permissible ambient light		Max. 40,000 lx (depending on CFS sensor)
Synchronization		Synchronization is possible
Supply voltage		18 ... 28 V DC
Max. current consumption		500 mA
Signal input		4 inputs (IN0–IN3): IN0 via keyboard; IN0–IN3 configurable via the website (trigger, teach, clear, lock, adjust)
Digital interface		RS232 (9600 baud standard), Ethernet, USB, Modbus (TCP/RTU) ^[3] ^[4]
Digital outputs		OUT0 - OUT7 Push-Pull / NPN / PNP (max. 30 kHz, color recognition, binary coding 254 color groups)
Connection	Optical	Screwable fiber optic cable via FA socket M18x1, length 0.3 m ... 2.4 m, min. bending radius 18 mm
	Electrical	Power/PLC: 8-pin flange connector M12A; signal: 8-pin flange socket M12A; Ethernet: 4-pin flange socket M12D (DHCP-capable); USB: 5-pin flange socket M12A
Mounting		DIN rail mounting/screw connection via adapter
Temperature range	Storage	-10 ... +85 °C
	Operation	-10 ... +55 °C
Humidity		20 % RH ... 80 % RH (non-condensing)
Shock (DIN EN 60068-2-27)		15g / 6 ms in 3 axes, two directions and 1000 shocks each
Vibration (DIN EN 60068-2-6)		2g / 10 ... 500 Hz in 3 axes, 10 cycles each
Protection class (DIN EN 60529)		IP65 (connected)
Material		Aluminum, anodized black
Weight		approx. 200 g
Compatibility		With all CFS sensors ^[5]
Control and indicator elements		Operation via keyboard and web interface, visualization with 13 white LEDs
Special features		Multicolor teach function, automatic adaptation of brightness, measurement signal amplification and averaging depending on measuring frequency, adjustable hold time of > 30 μ s

^[1] Maximum color difference ΔE of 1000 consecutive measurements from the color value of a red and a dark gray (R = 5%) reference tile, measured with sensor CFS4-A20 at 1000 Hz and brightness adjustment to white standard (R = 95%)

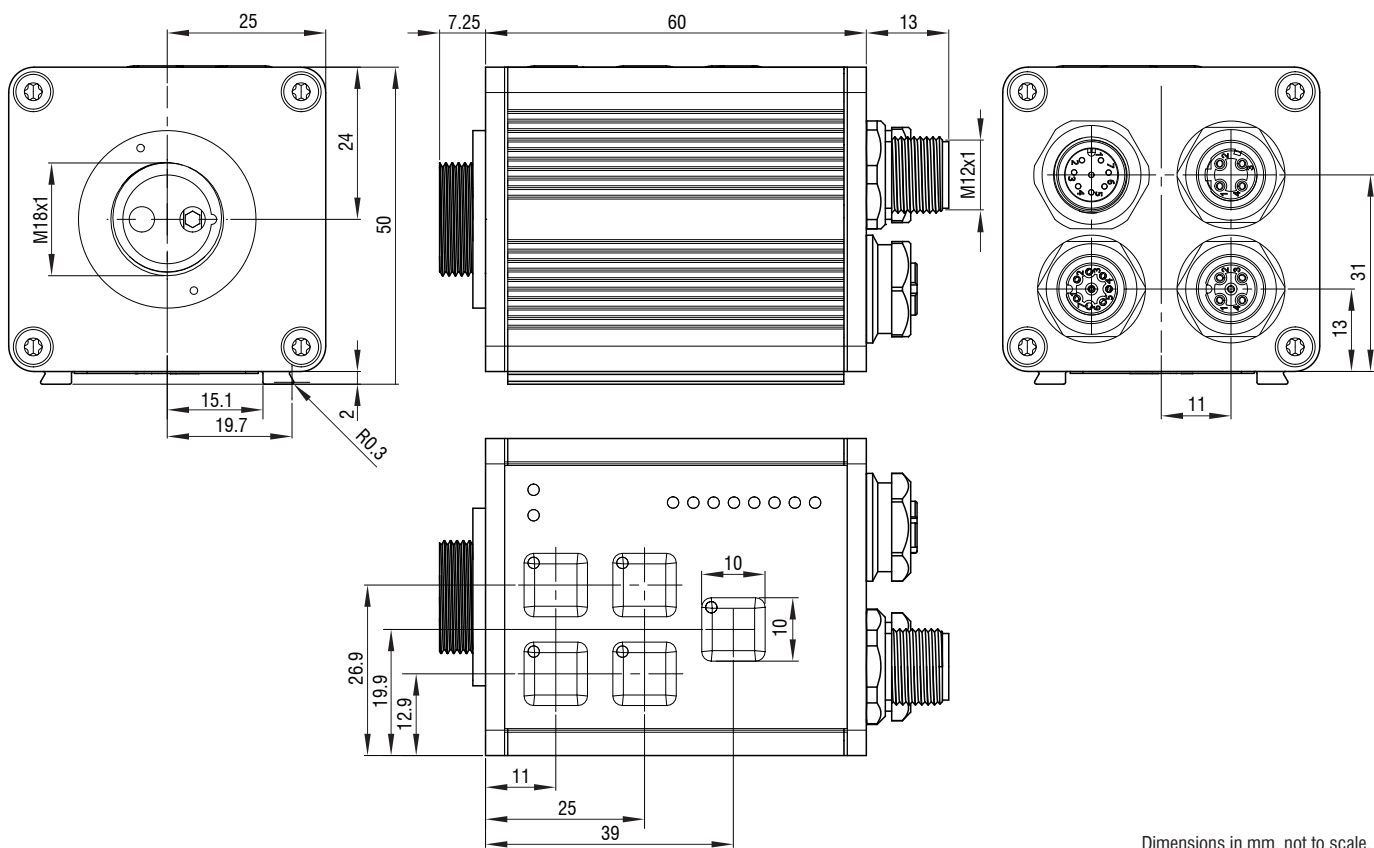
^[2] FSO = Full Scale Output

^[3] RS232 adjustable up to a maximum of 115,200 baud

^[4] Optional connection via PROFINET, EtherNet/IP or EtherCAT using an interface module

^[5] Also compatible with previous series (FAR, FAD, FAL, FAZ and FAS)

Dimensions:



Dimensions in mm, not to scale.