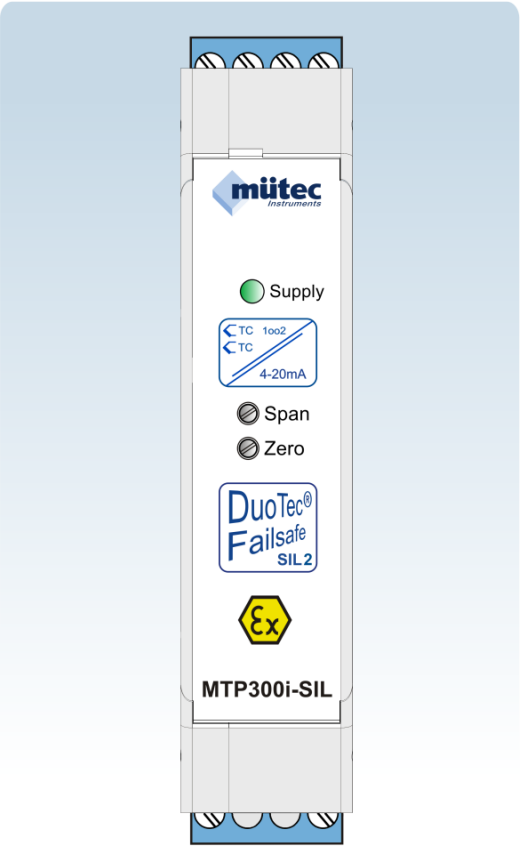
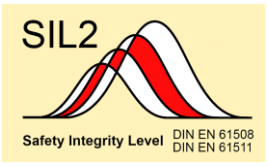
MTP300i-SIL-K

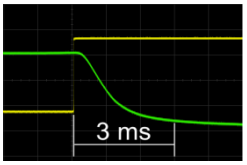
Loop-powered Transmitter for Thermocouple Type K (NiCr-Ni)



Properties

- 2-wire temperature transmitter for DIN rails
- Galvanic isolated TC-input with cold-junction compensation
- Signal pass-through time:
  without Butterworth filter ≤ 3 ms
  with Butterworth filter ≤ 38 ms
- Installation in zone 1 or 2 permissible
- Intrinsic safety according to IEC/EN 60079-11
- SIL 2 according to IEC/EN 61508:2010
- Error indication according to NAMUR NE 43
- LED status indication





Description

The 2-wire temperature transmitter **MTP300i-SIL-K** has been designed for the operation of intrinsically safe thermocouple circuits installed in the Ex area.
The TC input is equipped with a Pt100 sensor for the cold-junction compensation.
The TC transmitter must be intrinsically safe supplied by a repeater power supply or ZENER barrier. The thermocouple signal is galvanic isolated.
The device can be installed in zone 1 or 2 with the “n” (IEC/EN 60079-15) protection type.

WARNING: Explosion hazard
The device is an intrinsically safe electrical equipment for intrinsically safe circuits. It is designed for use in zone 1 or 2, if specific conditions are observed.
When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.
Observe also the safety regulations and installation notes on page 6.

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Table of Content

1 Technical Data

Certificate

Ex certificate	IECEx BVS 14.0073 X Ex ib [ia Ga] IIC T4 Gb
Functional Safety (SIL)	SIL 2 according to EN 61508

Safety data according to IECEx for intrinsically safe circuits

Power supply - Ex ib IIC (terminals 1 and 4)

Voltage	Ui	28 Vdc
Current	Ii	95 mA
Power	Pi	655 mW
Effective inner capacity	Ci	26 nF
Effective inner inductivity	Li	negligible

Thermocouple input - Ex ia IIC and Ex ib IIC (terminals 5 and 8, 9 and 12)

Voltage	Uo	1 Vdc
Current	Io	1.8 mA
Power	Po	0.5 mW
Permissible outer capacity	Co	10 µF
Permissible outer inductivity	Lo	100 mH

Input signal (terminals 5 and 8)

Thermocouple type NiCr-Ni	K	fixed range (see nameplate)
Cold-junction compensation with Pt100 sensor (see Fig. 3)		-10 … +70°C

Output signal (terminals 1 and 4)

Current proportional to the temperature	Io	4 … 20 mA
Maximum current	Io	< 24 mA
Behavior by failure (according to NE 43)	Io	≤ 3.6 mA

Status indicator for power supply respectively mA signal

Green LED	luminosity corresponds to 4 … 20 mA
Behavior by failure	off

General data

Signal pass-through time

Input to output without Butterworth filter	≤ 3 ms
Input to output with Butterworth filter	≤ 38 ms (default)

Transmission error

Typical	< 0.05 % (of final value)

Temperature coefficient

Typical	< 0.05 %/10 K

Pt100 sensor error

Class B: t = +/- (0.3°C + 0.005 x t)	< 0.23°C at 70°C

Cold-junction compensation error

Temperature range 0°C to +50°C	< 0.4°C
Temperature range -10°C to +70°C	< 1.0°C

Linearization error

Typical	< 0.1°C

Measured value deviation

Typical	< 0.6°C at 20°C

Electric isolation

Tested according norms & rules EN 60079-11

Electromagnetic compatibility

Tested according norms & rules EN 61326-3-2

Current loop supply

Voltage range (R_{Load} = 70 Ω … 800 Ω)	12.5 … 28 V
Current range	> 3.5 …< 24 mA

Power dissipation

Minimum (12.5 V x 4 mA)	50 mW
Maximum (28 V x 20 mA)	560 mW

Ambient temperature

Operation	-10°C to +70°C
Storage/transport	-20°C to +80°C

Humidity

Permissible operation humidity (no condensation)	10 % … 95 %

Housing

Material	Polyamide
Color	light grey
Degree of protection	IP20
Width x length x height (with connection terminal blocks)	22.5 x 115 x 108 mm
Inflammability class according to UL 94	V0
Housing type for mounting	35 mm DIN rails
Weight with terminal blocks	approx. 200 g

Connection data

Solid (minimum/maximum)	0.2 mm^2/2.5 mm^2
Stranded wire (minimum/maximum)	0.2 mm^2/2.5 mm^2
AWG/kcmil (minimum/maximum)	24/14
Stripping length	7 mm
Connection method	plugable screw connection
Tightening torque	0.5 … 0.6 Nm

Installation

Safe area:	Install the device in a clean and dry environment.
Ex area (zone 1 or 2):	Install the device in a suitable housing with a minimum of IP54 degree of protection.

Dimensions

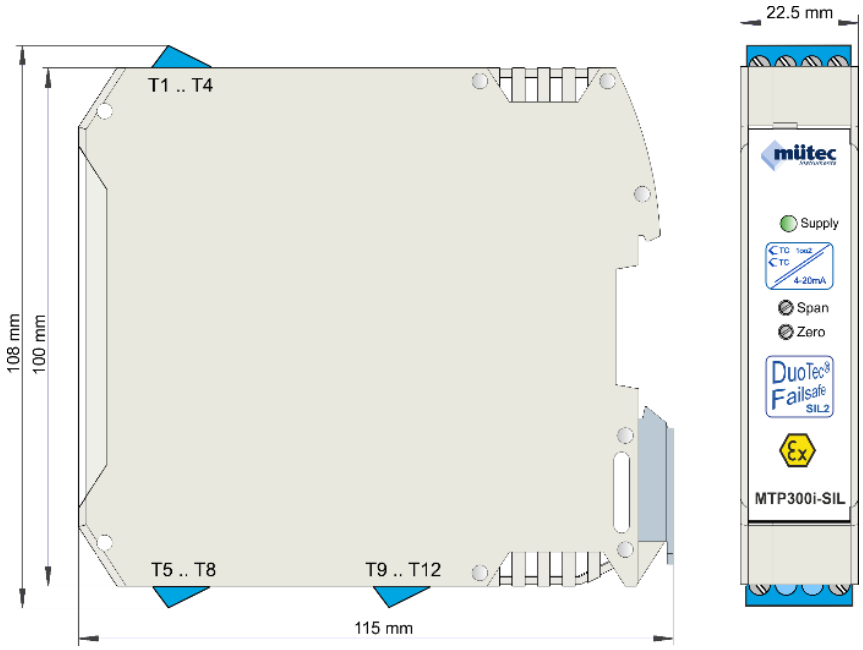


Fig. 1

ZERO and SPAN adjustment

Fig. 2

Pt100 cold-junction compensation error

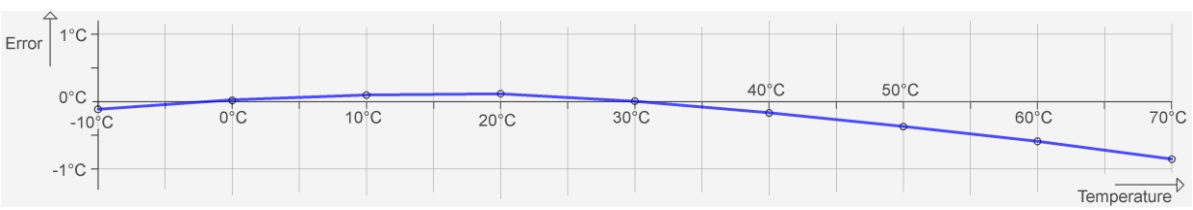


Fig. 3

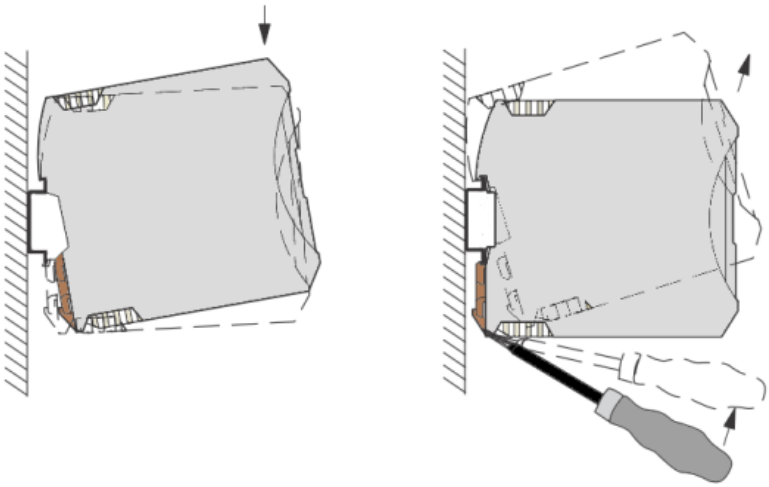
Mounting and removal:

Mount the module on a 35 mm DIN rail according to EN 60715

Install the module in a suitable housing to meet the requirements for the protection class

Mounting: Snap-on foot below (left part of drawing)

Removal: With a screwdriver (right part of drawing)



Before start up, check the correct wiring and labelling of the intrinsically safe circuits

Fig. 4

Connecting the cables: Permissible cable cross-section are 0.2 mm^2 to 2.5 mm^2 . Stranded wires provided with ferrules.

Screw connection: Insert the wire into the corresponding connection terminal block and use a screwdriver to tighten the screw in the opening above the connection terminal block.

2 Safety Regulations and Installation Notes

Follow the installation instructions:

NOTE: Installation, operation, and maintenance may only be carried out by qualified specialist personnel.

When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.

NOTE: The circuits inside the device must not be accessed.

Do not repair the device yourself, but replace it with an equivalent device. Repairs may only be carried out by the manufacturer.

NOTE: The device is suitable for IP20 degree of protection if:

- It is installed outside potentially explosive areas
- The environment is clean and dry

Install the device in a suitable housing with a suitable degree of protection in accordance with IEC 60529 in order to protect it from mechanical and electrical damage.
For the safety data, please refer to the operating instructions and certificates (EC examination certificate, other approvals, if necessary).

Safety regulations for installation in potentially explosive areas and regulations for intrinsically safe circuits:

WARNING: Explosion hazard
When carrying out measurements on the intrinsically safe side, be sure to observe the relevant regulations regarding the connection of intrinsically safe equipment.
Only use approved devices for use in intrinsically safe circuits.

WARNING: Explosion hazard
If the device has been used in non-intrinsically safe circuits, it must not be used again in intrinsically safe circuits.
Clearly label the module as being non-intrinsically safe.

Installation in zone 1 or 2:

WARNING: Explosion hazard
The device is an intrinsically safe equipment of the “Ex-i” protection type and suitable for installation in zone 1.

Observe the specified conditions for use in potentially explosive areas.

WARNING: Explosion hazard
Install the device in a suitable housing with a minimum of IP54 degree of protection and in accordance with DIN EN 60529.

Installation in areas with a danger of dust explosions:

WARNING: Explosion hazard
The device is not designed for installation in areas with a danger of dust explosions.

Connection to the intrinsically safe circuit in areas with a danger of dust explosions (zones 20, 21, and 22) is only permitted if the equipment connected to this circuit is approved for this zone (e.g., category 1D, 2D or 3D).

3 Installation

NOTE: Electrostatic discharge
The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and EN 61340-5-2.

Basic circuit diagram for 1 TC with connection terminals:

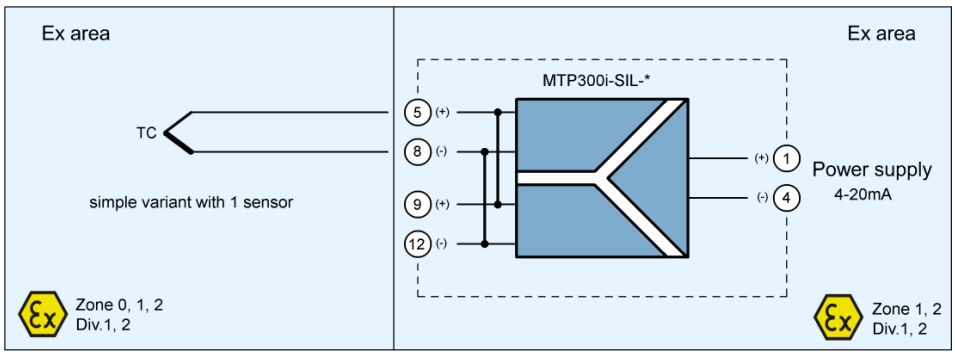


Fig. 5

Input (intrinsically safe):

Thermocouple with connection to terminal 5/+ and 8/-

Power supply/output signal (intrinsically safe):

Repeater power supply with connection to terminal 1/+ and 4/-

4 Comparison of Safety Data

WARNING: Explosion hazard
Compare the safety data before connecting a device located in the Ex-i area to the MTP300i-SIL-K.

Safety data for	**MTP300i-SIL-K**:	**U_i, I_i, P_i, L_i, C_i**
	Repeater power supply:	**U_o, I_o, P_o, L_o, C_o**

For the values for **U_o, I_o, P_o, L_o** and **C_o** please refer to “Safety data according to ATEX for intrinsically safe circuits” on page 2.

Ex-i requirements (simple circuits)

$U_i \geq U_o$
$I_i \geq I_o$
$P_i \geq P_o$
$L_i + L_c \leq L_o$ (L_c is depend on the cables/lines used)
$C_i + C_c \leq C_o$ (C_c is depend on the cables/lines used)

5 Principle of Function:

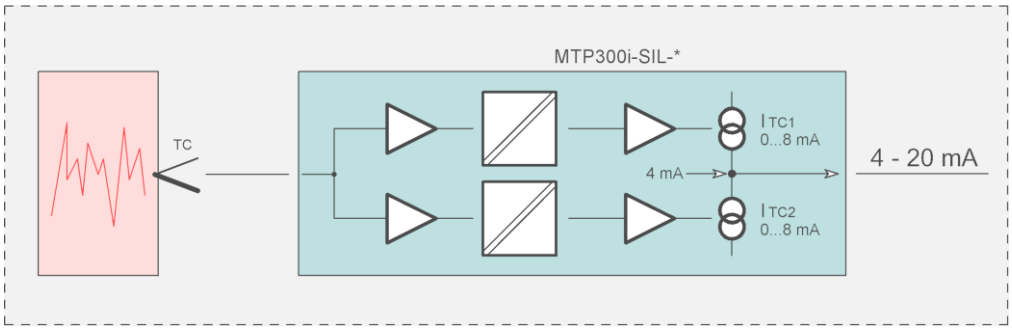


Fig. 6

The **MTP300i-SIL-K** has two galvanic isolated temperature channels and two separate constant current sources. This structure supports at best the diagnosis and monitoring of temperature sensors with wires and temperature measuring circuits.
All internal function blocks of the transmitter and the external circuits are subject of a continuous self-test. The failure information according to NE43 (NAMUR Recommendation) is a transmitter output signal < 3.6 mA.

6 Safety Function:

Activation of the **Safety Function: $I_a \leq 3.6$ mA**

A deviation > 4 % between the two galvanic isolated temperature channels or an internal failure leads to a value reduction of the mA output (< 3.6 mA). The output signal (see Fig. 6) returns after a break of about 7 to 9 seconds and the self monitoring checks again, whether the failure still is present and thus the shutdown must be repeated.
Only an external failure (Thermocouple or wire break) leads to a permanent reduction of the mA-value in the supply circuit (< 3.6 mA).

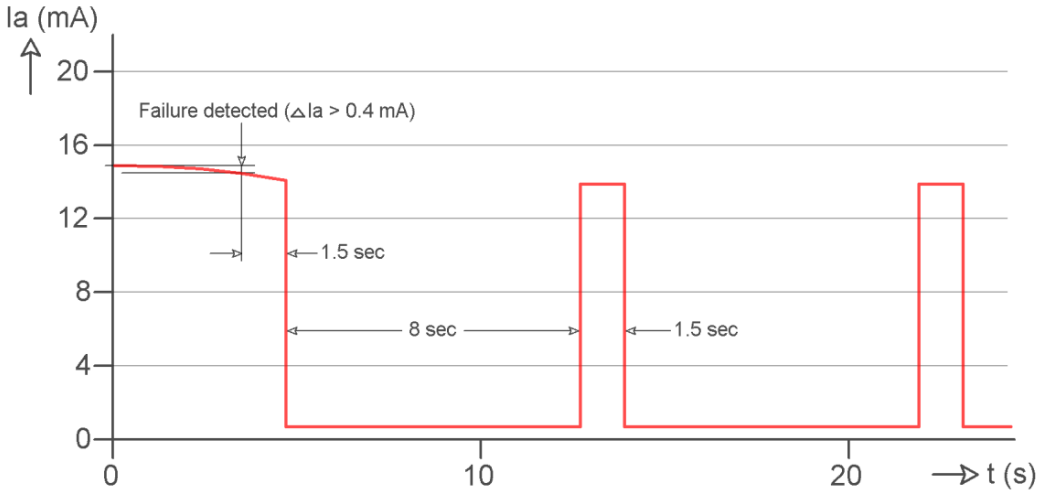


Fig. 7

The **MTP300i-SIL-K** has two galvanic isolated temperature channels with two separate constant current sources. This structure supports at best the diagnosis and monitoring of temperature sensors with wires and temperature measuring circuits.
All internal function blocks of the transmitter and the external circuits are subject of a continuous self-test. The failure information according to NE43 (NAMUR Recommendation) is a transmitter output signal < 3.6 mA.

Behavior of the output signal by external failure:

- Sensor or cable break
  The transmitter output signal is permanently limited < 3.6 mA.

- Short circuit
  The transmitter output signal corresponds to the Pt100 temperature value of the cold-junction compensation.

Behavior of the output signal by internal failure:

- Monitoring of the two measurement channels
  Exceeds the deviation the value of 0.4 mA, so the transmitter output signal jumps periodically to the value of < 3.6 mA.

- Monitoring of the internal supply voltage
  Exceeds the deviation the value of 5 %, so the transmitter output signal jumps periodically to the value of < 3.6 mA.

- Monitoring of the internal supply current
  Exceeds the deviation the value of 5 %, so the transmitter output signal jumps periodically to the value of < 3.6 mA.

- Monitoring of the clock frequency
  Exceeds the deviation of clock frequency the value of 10 %, so the transmitter output signal jumps periodically to the value of < 3.6 mA.

7 Safety Applications for SIL 2

Safety integrity requirements (see also technical report **4.139.18/Risknowlogy**)

Failure rates of temperature measurement channels:
Type A device (according to IEC/EN 61508-2), Safety Integrity Level (SIL 2)

λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF
0 FIT	78.5 FIT	61.3 FIT	4.7 FIT	96.8 %

λ_{su} includes failure that not cause a spurious trip
SFF = Safe Failure Fraction
FIT = Failure In Time (1 FIT = 1 failure / 10^9 h)

PFD_{AVG} values of MTP300i-SIL-K without TC-sensor(s):
The beta factor is 2 % and was derived from IEC/EN 61508-6, Annex D

T [PROOF]	**1 Year**	**2 Years**	**5 Years**	**10 Years**	**20 Years**
PFD_{AVG}	5.63E-05	1.11E-04	2.77E-04	5.54E-04	1.11E-03
% SIL 2	0.56 %	1.11 %	2.77 %	5.54 %	11.07 %

PFD_{AVG} = Average value of the Probability of Failure on Demand
T [PROOF] = Proof test interval

The calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC/EN 61508-1, and do fulfill the requirement to not cover more than 11.1% of this range after 20 years.

PFS_{AVG} for 1 Year: **2.63E-05**

PFS_{AVG} = Average value of the Probability of Fail Safe

Failure limit:
The operating mode is based on low demand mode.
The proportion of MTP300i-SIL on the PFD_{AVG} of safety chain shall be not more 15 %.

Sensors (2xTC)	MTP300i-SIL	Repeater power supply	Processing
35 %	**15 %**	**35 %**	**15 %**

Conditions:

- The failure rates of the components used remain constant throughout the period of use.
- Propagation of errors by the device in the system is not taken into consideration.
- The repair time (= replacement) should be 72 hours.
- The average temperature at which the device is to be used is +40°C. This is based on standard industrial conditions.
- The failure rates given refer to an ambient temperature of +40°C. For an ambient temperature of +60°C, you will need to multiply the failure rates by a factor of 2.5. The factor is based on empirical values gathered.

Proof test

Carry out the appropriate steps to prevent incorrect use.
Example for TC type K:
An input signal of 0…16.395 mV corresponds to a temperature range of 0 to 400°C.
The output must be set to 4.00…20.00 mA.
Setting ≤ 3.6 mA or > 22 mA verifies that the subsequent processing can provide signals outside the range.
In the event of an error, the device must be replaced by an equivalent device.
Restore the safety circuit to full functionality.
Return to normal operation.

8 PFD Calculations

Failure rate of TC sensor:

	TC sensor without extension wire				TC sensor with extension wire			
	s [FIT]	d [FIT]	DC	SFF	s [FIT]	d [FIT]	DC	SFF
Low Stress	40	9	95 %	81.63 %	381	95	95 %	80.04 %
High Stress	787	173	95 %	81.98 %	7600	1900	95 %	80.00 %

Failure rate of extension wire:

	Extension wire			
	s [FIT]	d [FIT]	DC	SFF
Low Stress	341	86	95 %	79.86 %
High Stress	6813	1727	95 %	79.96 %

Failure rate of TC sensor with extension wire by high stress:

T [PROOF]	**1 Year**	**2 Years**	**5 Years**	**10 Years**	**20 Years**
tce	291	510	1167	2262	4452
PFD_{AVG} Sensor + Wire	5.53E-04	9.69E-04	2.22E-03	4.30E-03	8.46E-03

PFD formula for TC sensor:

$$PFD_{AVG}\ \text{Sensor} \approx 0.5 \times \lambda_{du} \times T \qquad \lambda_{du} = (1 - DC) \times \lambda_d$$

Failure rate of a transmitter with measuring circuit:

T [PROOF]	**1 Year**	**2 Years**	**5 Years**	**10 Years**	**20 Years**
PFD_{AVG} Sensor+Wire	5.53E-04	9.69E-04	2.22E-03	4.30E-03	8.46E-03
PFD_{AVG} MTP300i	5.63E-05	1.11E-04	2.77E-04	5.54E-04	1.11E-03
PFD_{AVG} total	6.09E-04	1.08E-03	2.49E-03	4.85E-03	9.57E-03
% SIL 2	6.1 %	10.8 %	24.9 %	48.5 %	95.7 %

PFD formula for transmitter with measuring circuit:

$$PFD_{AVG}\ \text{total} = PFD_{AVG}\ \text{Sensor + Wire} + PFD_{AVG}\ \text{MTP300i}$$