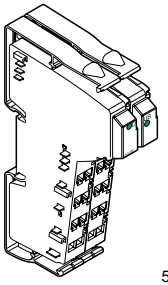
# VARIO AO 1/SF

## I/O Extension Module
## With One Analog Output



5562A001

User Manual 02/2003

All modules will be delivered including connectors and labeling fields

This data sheet is only valid in association with the documents of the used fieldbus coupler

Only **one** output must be used on the terminal. Use a connector with shield connection when installing the actuator.

## Function

The terminal is designed for use within an VARIO station. It is used to output analog voltage or current signals. The signals are available with a resolution of 16 bits.

### Features

- One analog signal output to connect either voltage or current signals
- Actuator connection in 2-wire technology with shield connection
- Two current ranges, one voltage range: 0 mA to 20 mA, 4 mA to 20 mA 0 V to 10 V
- Process data update including conversion time of the digital-to-analog converter < 1 ms

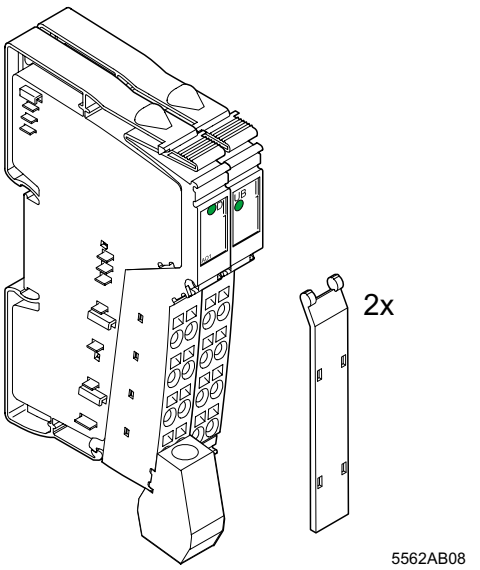



Figure 1 module VARIO AO 1/SF with connectors to output voltages

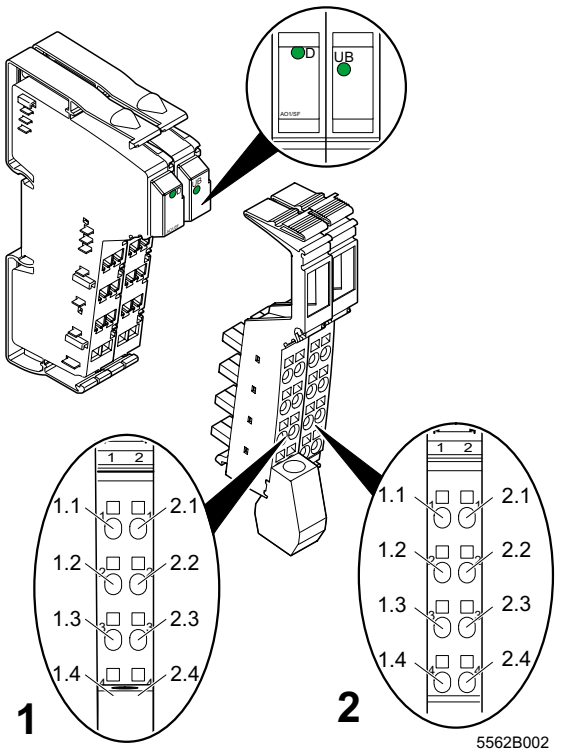



Figure 2 VARIO AO 1/SF
with appropriate connectors

**Local LED Diagnostic and Status Indicators**

| Des. | Color | Meaning |
|---|---|---|
| **D** | Green | Bus diagnostics |
| **UB** | Green | I/O voltage for analog terminals present (current level) |

**Terminal Assignment**

| Connector | Terminal Point | Signal | Assignment |
|---|---|---|---|
| **1** | **1.1** | **U** | Voltage output 0 V to 10 V |
| | **2.1** | **–** | Not used |
| **2** | **1.1** | **I** | Current output 0 mA to 20 mA |
| | **2.1** | **I** | Current output 4 mA to 20 mA |
| **1 and 2** | **1.2, 2.2** | **–** | Not used |
| | **1.3, 2.3** | **GND** | Ground |
| | **1.4, 2.4** | **Shield** | Shield connection |

## Installation Instructions

High current flowing through the potential jumpers $U_M$ and $U_S$ leads to a temperature rise of the potential jumpers and the inside of the terminal. Observe the following instructions to keep the current flowing through the potential jumpers of the analog terminals as low as possible:

Create a separate main circuit for each analog terminal.

If this is not possible in your application and if you are using analog terminals in a main circuit together with other terminals, place the analog terminals behind all the other terminals at the end of the main circuit.

Please note the derating curve on page 12.

# Internal Circuit Diagram

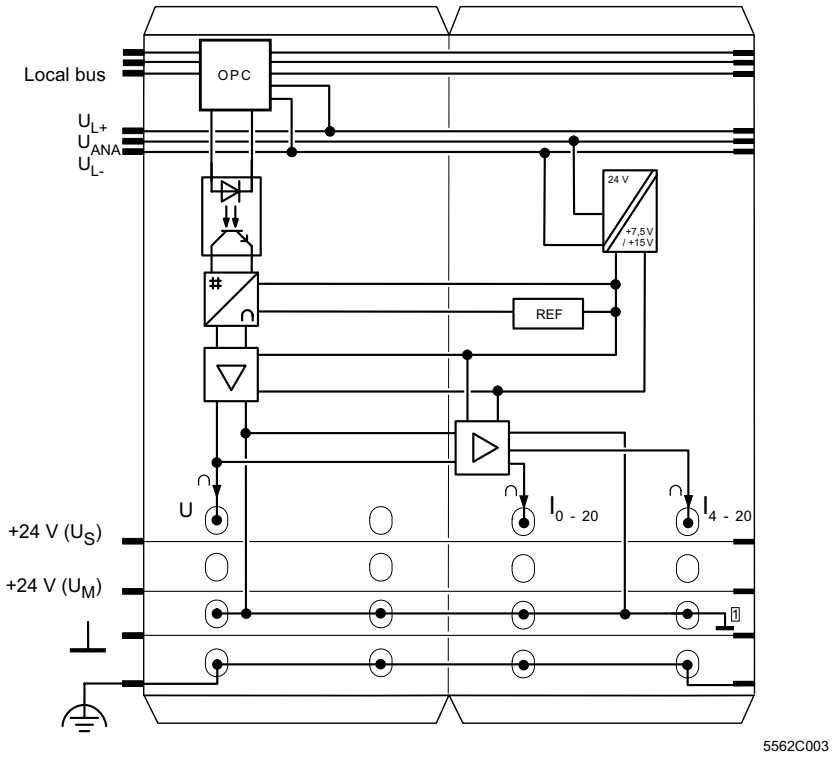



Figure 3 Internal wiring of the terminal points

Key:

| | | | |
|---|---|---|---|
| OPC | Protocol chip | | Amplifier |
| | Optocoupler | | Digital-to-analog converter |
| | DC/DC converter with electrical isolation | | Analog output |
| REF | Reference voltage | 1 | Analog ground, electrically isolated from ground of the potential jumper |

# Electrical Isolation

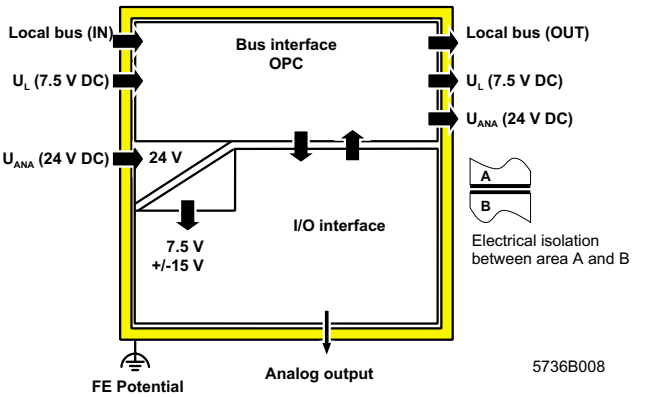



Figure 4 Electrical isolation of the individual function areas

# Connection Notes

**Always** connect the analog actuator using shielded, twisted pair cables.

Connect one end of the shielding to PE. At the module, fold the outer cable sheath back and connect the shield to the terminal via the shield clamp. The clamp connects the shield directly to FE on the terminal side.

When using cables longer than 10 m (32.81 ft.) in environments prone to interference, we recommend connecting the shield on the actuator to the FE potential via an RC element. Typically, the capacitor C should be rated between 1 and 15 nF. The resistor R should be at least 10 MΩ.

Use an I/O connector with shield connection when installing the actuator. On the base side that is not used to connect an actuator, you may use one of the connectors listed in the ordering data. The appearance of the module differs depending on the output used. This is shown in Figure 5 and Figure 6 in the top left corner.

# Connection Examples

Use a connector with shield connection when installing the actuator. Figure 5 and Figure 6 show the connection schematically (without shield connector).

### Voltage Output

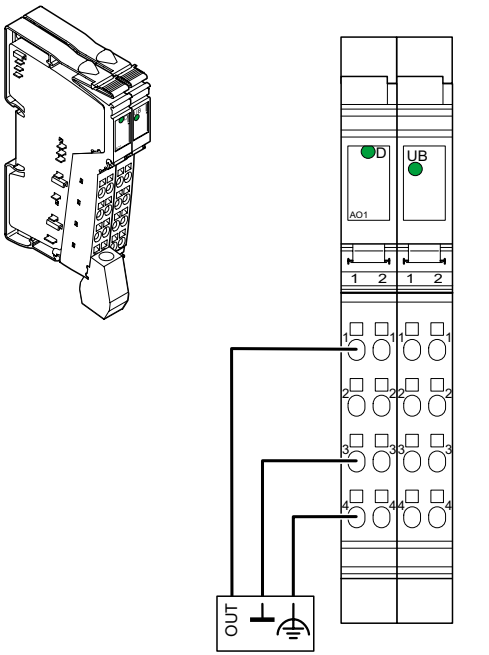



Figure 5 Actuator connected to the voltage output 0 V to 10 V in 2-wire technology with shield connection

### Current Output

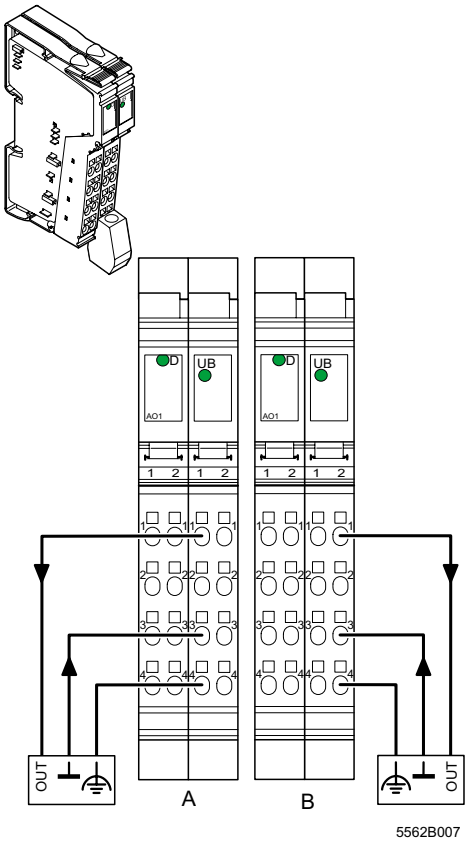



Figure 6 Actuator connected to the current outputs in 2-wire technology with shield connection

A Signals for actuator at the current output 0 mA to 20 mA

B Signals for actuator at the current output 4 mA to 20 mA

# Programming Data

### General

| | |
|---|---|
| ID code | $7D_{hex}$ ($125_{dec}$) |
| Length code | $01_{hex}$ |
| Input address area | 0 bytes |
| Output address area | 2 bytes |
| Parameter channel (PCP) | 0 bytes |
| Register length (bus) | 2 bytes |

### Different Fieldbus Systems

For the programming data of other bus systems, please refer to the appropriate electronic device data sheet (GSD, EDS).

# Process Data Words

### Assignment of the Terminal Points to the Process Data Output Word

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| "Word.bit" view | Word | Word x | | | | | | | | | | | | | | | |
| | Bit | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| "Byte.bit" view | Byte | Byte 0 | | | | | | | | Byte 1 | | | | | | | |
| | Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Terminal points slot 1 | Signal | Terminal point 1.1: Voltage output | | | | | | | | | | | | | | | |
| | Signal reference | Terminal point 1.3, 2.3 | | | | | | | | | | | | | | | |
| | Shielding (FE) | Terminal point 1.4, 2.4 | | | | | | | | | | | | | | | |
| Terminal points slot 2 | Signal | Terminal point 1.1: Current output 0 to 20 mA<br>Terminal point 2.1: Current output 4 to 20 mA | | | | | | | | | | | | | | | |
| | Signal reference | Terminal point 1.3, 2.3 | | | | | | | | | | | | | | | |
| | Shielding (FE) | Terminal point 1.4, 2.4 | | | | | | | | | | | | | | | |

### OUT Process Data Output Word

The process data output word specifies the output value in each cycle.

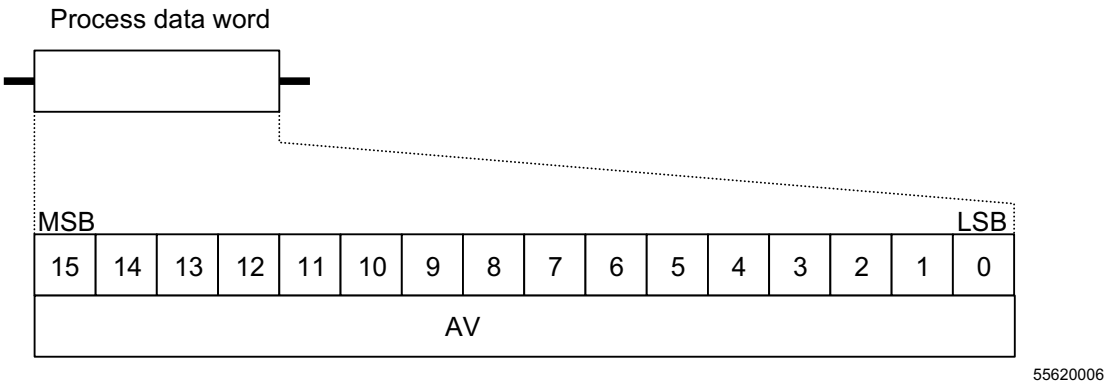



Figure 7 Process data output word

AV Analog value
MSB Most significant bit
LSB Least significant bit

All output values are displayed with 16-bit resolution.

For significant values in the process data word, refer to the following tables.

Abbreviations used in the following tables:

| | | | |
|---|---|---|---|
| QS | Quantization step(s) | ORF | Output range final value |
| MSB | Most significant bit | LSB | Least significant bit |

| **OUT Process Data Output Word for the Voltage Output 0 V to 10 V (Example)** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Voltage Output **0 V to 10 V** | Analog Value (V) | Process Data Output Word | | | | | | | | | | | | | | | | |
| | | Hex. | Binary (Two's Complement) MSB LSB | | | | | | | | | | | | | | | |
| | | | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 10 V minus 1 QS | 9.99985 | FFFF | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 V minus 2 QS | 9.99969 | FFFE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Half ORF | 5.0000 | 8000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 QS | 0.153 mV | 0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Zero | 0.0000 | 0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **OUT Process Data Output Word for the Current Output 0 mA to 20 mA (Example)** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Output **0 mA to 20 mA** | Analog Value (mA) | Process Data Output Word | | | | | | | | | | | | | | | | |
| | | Hex. | Binary (Two's Complement) MSB LSB | | | | | | | | | | | | | | | |
| | | | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 20 mA minus 1 QS | 19.9997 | FFFF | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 mA minus 2 QS | 19.9994 | FFFE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Half ORF | 10.000 | 8000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 QS | 0.305 µA | 0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Zero | 0.0000 | 0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| **OUT Process Data Output Word for the Current Output 4 mA to 20 mA (Example)** | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Current Output **4 mA to 20 mA** | Analog Value (mA) | Process Data Output Word | | | | | | | | | | | | | | | | |
| | | Hex. | Binary (Two's Complement) MSB LSB | | | | | | | | | | | | | | | |
| | | | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 20 mA minus 1 QS | 19.99998 | FFFF | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 mA minus 2 QS | 19.99995 | FFFE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Half ORF | 12.0000 | 8000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 mA plus 1 QS | 4.000244 | 0001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Output range start | 4.0000 | 0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Output Behavior of the Voltage or Current Output

Take the behavior of the output in the event of an error into account when planning your system.

| Switching Operation/State of the Supply Voltage | Marginal Condition | OUT Process Data Word (hex) | Behavior/Status of the Analog Output | | |
|---|---|---|---|---|---|
| | | | 0 V to 10 V | 0 mA to 20 mA | 4 mA to 20 mA |
| $U_{ANA}$ from 0 V to 24 V | $U_L$ = 0 V | xxxx | 0 V | 0 mA | 4 mA |
| $U_{ANA}$ from 24 V to 0 V | $U_L$ = 7.5 V | xxxx | 0 V | 0 mA | 0 mA |
| Bus in STOP state | $U_{ANA}$ = 0 V | xxxx | 0 V | 0 mA | 0 mA |
| Bus in STOP state | $U_{ANA}$ = 24 V | xxxx | Maintains last value | | |

$U_{ANA}$ Analog supply voltage of the terminal

$U_L$ Supply voltage of the module electronics (communications power)

xxxx Any value in the range from $0000_{hex}$ to $FFFF_{hex}$.

The behavior and status of the output depends on the output used.

**Response of the Control System or Computer to a Hardware Signal for Different Control or Computer Systems**

| Signal | Control or Computer System | Status After the Switching Operation | | |
|---|---|---|---|---|
| | | OUT Process Data Output Word | Analog Output | |
| | | | $U_{out}$ | $I_{out}$ |
| NORM* | AEG Schneider Automation | 0000 | 0 V | 0 mA/4 mA |
| BASP | Siemens S5 | 0000 | 0 V | 0 mA/4 mA |
| CLAB | Bosch | 0000 | 0 V | 0 mA/4 mA |
| SYSFAIL | VME | 0000 | 0 V | 0 mA/4 mA |
| SYSFAIL | PC | 0000 | 0 V | 0 mA/4 mA |
| CLEAR OUT | Moeller IPC | 0000 | 0 V | 0 mA/4 mA |

* On controller boards for AEG Schneider Automation control systems it is possible to set the NORM signal so that the OUT process data output word and the analog output maintain the last value.

The status of the current output depends on the range selected.

**Response of the Voltage and Current Outputs to a Control Command of the Controller Board**

| Command | Status After the Switching Operation | | |
|---|---|---|---|
| | OUT Process Data Output Word | Analog Output | |
| | | $U_{out}$ | $I_{out}$ |
| STOP | Maintain last value | Maintain last value | Maintain last value |
| ALARM STOP (reset) | Maintain last value | Maintain last value | Maintain last value |

# Technical Data

| General | |
|---|---|
| Housing dimensions (width x height x depth) | 24.4 mm x 120 mm x 71.5 mm<br>(0.961 x 4.724 x 2.815 in.) |
| Weight | 90 g (without connectors), 100 g<br>(including connectors) |
| Operating mode | Process data mode with 1 word |
| Type of actuator connection | 2-wire technology |
| Permissible temperature (operation) | -25°C to +55°C (-13°F to +131°F) |
| Permissible temperature (storage/transport) | -25°C to +85°C (-13°F to +185°F) |
| Permissible humidity (operation) | 75% on average, 85% occasionally |

In the range from -25°C to +55°C (-13°F to +131°F) appropriate measures against increased humidity (> 85%) must be taken.

| | |
|---|---|
| Permissible humidity (storage/transport) | 75% on average, 85% occasionally |

For a short period, slight condensation may appear on the outside of the housing if, for example, the terminal is brought into a closed room from a vehicle.

| | |
|---|---|
| Permissible air pressure (operation) | 80 kPa to 106 kPa<br>(up to 2000 m [6562 ft.] above sea level) |
| Permissible air pressure (storage/transport) | 70 kPa to 106 kPa<br>(up to 3000 m [9843 ft.] above sea level) |
| Degree of protection | IP 20 according to IEC 60529 |
| Class of protection | Class 3 according to VDE 0106, IEC 60536 |

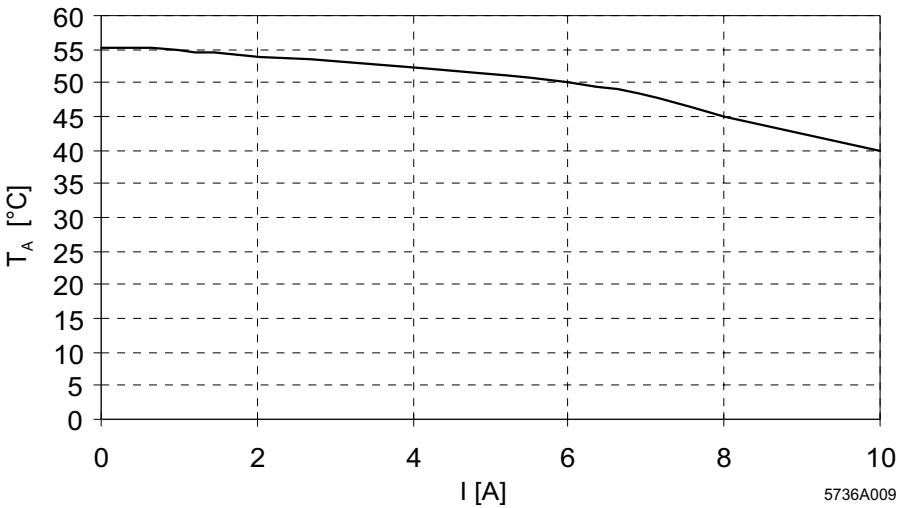
| Deviations From Common Technical Data That Is Indicated in the User Manual | |
|---|---|
| **Mechanical Requirements** | |
| Shock test<br>according to EN 60068-2-27, IEC 60068-2-27 | 15g load for 11 ms, half sinusoidal wave, three shocks in each space direction and orientation<br>25g load for 6 ms, half sinusoidal wave, three shocks in each space direction and orientation |

| Interface | |
|---|---|
| Local bus | Through data routing |

| Power Consumption | |
|---|---|
| Communications power $U_L$ | 7.5 V |
| Current consumption from $U_L$ | 30 mA, typical; 40 mA, maximum |
| I/O supply voltage $U_{ANA}$ | 24 V DC |
| Current consumption at $U_{ANA}$ | 50 mA, typical; 65 mA, maximum |
| Total power consumption | 1.425 W (typical) |

| Supply of the Module Electronics and I/O Through Bus Terminal/Power Terminal | |
|---|---|
| Connection method | Potential routing |

**Derating: Permissible Ambient Temperature Depending on the Current of the Voltage Jumpers $U_M$ and $U_S$ (Total Current)**




$T_A$ [°C] Ambient temperature in °C

I [A] Current flowing through potential jumpers $U_M$ and $U_S$ (A)

| **Analog Output** | | | |
|---|---|---|---|
| Number | | 1; configured depending on the terminal point used | |
| Signals/resolution in the process data word (quantization) | | | |
| Voltage | 0 to 10 V | 0 to 9.99985 V | 0.153 mV/LSB |
| Current | 0 to 20 mA | 0 to 19.9997 mA | 0.305 µA/LSB |
| | 4 to 20 mA | 4 to 19.99976 mA | 0.244 µA/LSB |
| Measured value representation | | 16-bit straight binary | |
| Basic error limit in the current range | | ±0.05%, typical | |
| Output load | | | |
| Voltage output | | 2 kΩ, minimum | |
| Current output | | 500 Ω, maximum | |
| Process data update including conversion time of the digital-to-analog converter | | 1 bus cycle (dependent on the bus configuration); < 1 ms | |
| Slew rate (> 99% of final value) | | < 10 µs | |

| **Tolerance Behavior and Temperature Response of the Voltage Output (The error indications refer to the output range final value of 10 V.)** | | |
|---|---|---|
| | **Typical** | **Maximum** |
| **Error at 23°C (73.4°F)** | | |
| Total offset voltage | ±0.03% | ±0.05% |
| Gain error | ±0.10% | ±0.15% |
| Differential non-linearity | ±0.0012% | ±0.003% |
| **Total error at 23°C (73.4°F)** | ±0.15% | ±0.25% |
| **Temperature response at -25°C to +55°C (-13°F to +131°F)** | | |
| Offset voltage drift $T_{KVO}$ | ±10 ppm/K | ±65 ppm/K |
| Gain drift $T_{KG}$ | ±30 ppm/K | ±35 ppm/K |
| Total voltage drift $T_{Ktot} = T_{KVO} + T_{KG}$ | ±40 ppm/K | ±100 ppm/K |
| **Total error of the voltage outputs (-25°C to +55°C [-13°F to +131°F]) Offset error + gain error + linearity error + drift error** | ±0.30% | ±0.60% |

| Tolerance Behavior and Temperature Response of the Current Output (0 mA to +20 mA) (The error indications refer to the output range final value of 20 mA.) | | |
|---|---|---|
| | **Typical** | **Maximum** |
| **Offset error at 23°C (73.4°F)** | | |
| Offset current $I_{oc}$ | ±0.05% | ±0.15% |
| Gain error | ±0.09% | ±0.25% |
| Differential non-linearity | ±0.0012% | ±0.003% |
| **Total error at 23°C (73.4°F)** | ±0.15% | ±0.25% |
| **Temperature response at -25°C to +55°C (-13°F to +131°F)** | | |
| Offset current drift $T_{KIO}$ | ±25 ppm/K | ±65 ppm/K |
| Gain drift $T_{KG}$ | ±10 ppm/K | ±35 ppm/K |
| Total current drift $T_{Ktot} = T_{KIO} + T_{KG}$ | ±35 ppm/K | ±100 ppm/K |

| Tolerance Behavior and Temperature Response of the Current Output (4 mA to +20 mA) (The error indications refer to the output range final value of 20 mA.) | | |
|---|---|---|
| | **Typical** | **Maximum** |
| **Offset error at 23°C (73.4°F)** | | |
| Offset current $I_{oc}$ | ±0.15% | ±0.45% |
| Gain error | ±0.25% | ±0.45% |
| Differential non-linearity | ±0.003% | ±0.005% |
| **Total error at 23°C (73.4°F)** | ±0.25% | ±0.46% |
| **Temperature response at -25°C to +55°C (-13°F to +131°F)** | | |
| Offset current drift $T_{KIO}$ | ±28 ppm/K | ±70 ppm/K |
| Gain drift $T_{KG}$ | ±15 ppm/K | ±40 ppm/K |
| Total current drift $T_{Ktot} = T_{KIO} + T_{KG}$ | ±43 ppm/K | ±110 ppm/K |

| Additional Tolerances Influenced by Electromagnetic Fields | | |
|---|---|---|
| **Type of Electromagnetic Interference** | **Criterion** | **Typical Relative Deviation of the Measuring Range Final Value** |
| Electromagnetic fields<br>Field strength 10 V/m<br>according to EN 61000-4-3/IEC 61000-4-3 | A | < 1% |
| Fast transients (bursts)<br>Supply 2 kV, output 1 kV<br>according to EN 61000-4-4/IEC 61000-4-4 | B | < 1% |
| Conducted interference<br>Class 3 (test voltage 10 V)<br>according to EN 61000-4-6/IEC 61000-4-6 | A | < 6% |

| Safety Devices | |
|---|---|
| None | |

**Electrical Isolation/Isolation of the Voltage Areas**

The electrical isolation of the logic level from the I/O area is ensured by the DC/DC converter.

**Common Potentials**

24 V I/O voltage, 24 V segment voltage, and GND have the same potential. FE is a separate potential area.

**Separate Potentials in the System Consisting of Bus Terminal/Power Terminal and I/O Terminal**

| - Test Distance | - Test Voltage |
|---|---|
| 7.5 V supply (bus logic)/24 V supply $U_{ANA}$/I/O | 500 V AC, 50 Hz, 1 min. |
| 7.5 V supply (bus logic)/24 V supply $U_{ANA}$/functional earth ground | 500 V AC, 50 Hz, 1 min. |
| 24 V supply (I/O)/functional earth ground | 500 V AC, 50 Hz, 1 min. |

| Error Messages to the Higher-Level Control or Computer System | |
|---|---|
| Failure or insufficient communications power $U_L$ | Yes, I/O error message sent to the bus coupler |

# Ordering Data

| Description | Order Designation | Order No. |
|---|---|---|
| Module with one analog output to output either voltage or current signals;<br>including connectors and labeling fields | VARIO AO 1/SF | KSVC-103-00211 |

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