VARAN Stepper Module VST 012

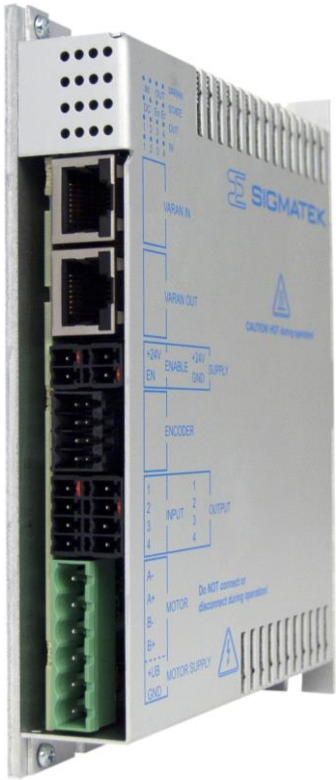
The VST 012 is a VARAN module designed for the control of a stepper motor up to a maximum 10 A RMS. The available operating modes are full step, half step and micro step. The maximum switching frequency of the output stage is 50 kHz.

The motor output is released through the Enable input.

An incremental encoder input is available for position control of the stepper motor.

The module also provides 4 digital inputs and 4 digital outputs.

The VARAN-Out port allows the configuration of the VARAN bus in a linear structure.



Safety Guidelines

The following safety guideline must be observed when operating the VST 012:

Warning! Dangerous electrical voltage!

During operation of the stepper motor output stage, dangerous voltages are generated. Only qualified personnel can work on this unit!

Failure to follow these instructions can lead to death, serious injury or damage to the machine.

Warning! Hot surface!

During operation, the output stage of the stepper motor can get hot. Avoid contact during operation!

Failure to follow the above safety measures can lead to severe injuries.

Technical Data

Interface

Interfaces	1 x VARAN-IN (RJ45) 1 x VARAN-Out (RJ45) (maximum length: 100 m)

Incremental encoder input

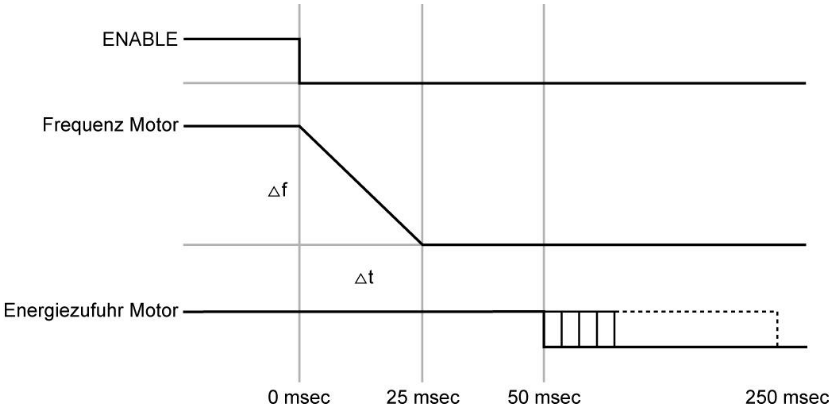
Number of channels	1
Input signals	Incremental encoder signals (A, /A, B, /B, R, /R) RS422 level 150 Ω termination
Input frequency	Maximum 250 kHz
Counter frequency	Maximum 1 MHz
Signal evaluation	4X
Counter resolution	16 bits
Power supply	+5 V / ±5 % / 0.2 A short circuit protected
Encoder cable length	Maximum 30 m

Enable input

Number	1	
Input voltage	Typically +24 V	Maximum +30 V
Signal level	Low: < +5 V	High: > +14 V
Switching threshold	Typically +9,5 V	
Input current	5 mA at +24 V	
Input delay	Typically 5 ms	
Status display	Green LED	

With the Enable input, the motor output is released through the hardware. As soon as the software enable is set, the Status LED lights and the motor output are released. When the Enable input drops, the ramping down of the motor can be initiated. By setting the delta frequency register and the delta time register, the ramp can be set through the hardware. A further option is ramping down through the software. A correct ramp down process must be performed within 50 msec after the Enable input falls. After this time, the energy supply to the motor is disconnected when the output stage is shut down through hardware.

Example of a 25 ms ramp-down process



Digital inputs

Number	4	
Input voltage	Typically +24 V	Maximum +30 V
Signal level	Low: < +5 V	High: > +14 V
Switching threshold	Typically +9,5 V	
Input current	5 mA at +24 V	
Input delay	Typically 10 µs	
Status display	Green LEDs	

Digital outputs

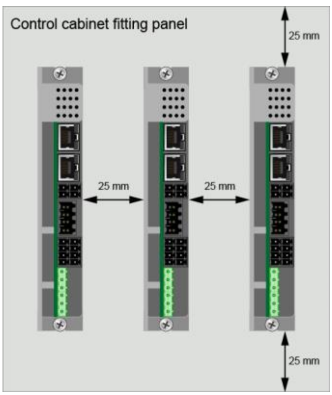
Number	4
Short-circuit proof	Yes
Maximum permitted continuous load current / channel	2 A
Maximum total current (entire module)	6 A (100 % of on time)
Residual current Off	≤ 12 µA
Turn-on delay	< 400 µs
Turn-off delay	< 400 µs
Status display	Yellow LEDs

Stepper motor output

Number of phases	2
Output voltage	Dependent on the supply (18 – 60 V)
Controller frequency	Maximum 50 kHz
Output current	Maximum 10 A continuous current in full step mode Maximum 10 A continuous current in half step mode [1a)] Maximum 10 A RMS continuous current in micro step mode [1)]
Output current over the environmental temperature	Maximum 10 continuous current at 45 °C [2)] Maximum 8.6 continuous current at 50 °C [2)] Maximum 6.3 continuous current at 55 °C [2)] Maximum 5 continuous current at 60 °C [2)]
Intermediate circuit capacitance	440 µF
Step resolution	32 micro steps per full step
Voltage measurement	15 – 73 V With an under voltage < 15 V or over voltage > 73 V, the motor output is shut down through the hardware.
Temperature measurement	45 °C – 125 °C using an NTC at the mounting bracket Temperature warning at 85 °C → software warning Over temperature at 95 °C → hardware shutdown of the motor output
Motor cable length	Maximum 30 m

1) In the operation modes half and micro step, the current amplitude is raised by a factor of √2. With this current increase, nearly 95 % of the full step torque and in micro step mode, 100 % of full step torque. In half step mode, the current increase must be activated through the software.

2) The specified output currents are only reached with additional cooling. This is normally achieved by mounting the component group on a good heat-dissipating (metal) surface. In the installation shown below, a clearance of at least 25 mm must be provided between two modules to ensure optimal cooling.



3) For motors with a phase current ≤ 3.5 A SIGMATEK recommends using the VST 011 module (16-014-011) because of the higher precision of the current measurement.

Frequency resonance

Operating a stepper motor can lead to resonance in certain frequency ranges. This is indicated by loss or torque reduction => the stepper motor loses steps. This phenomenon is a condition of the stepper motor construction and depends on the load. The problem can be minimized or avoided by half or micro step operation.

Electrical requirements

Power supply +24 V	18 - 30 V DC (1)
Current consumption Power supply +24 V	Maximum 300 mA (electronic supply) + load on the digital outputs
Supply voltage Stepper Motor	18 – 60 V DC
Current consumption of stepper motor supply	Corresponds to the load on the stepper motor

(1) The supply must be galvanically isolated (double or reinforced insulation) from the mains (300 V overvoltage category II).

Braking a stepper motor

When braking a stepper motor, a generative process can occur whereby the kinetic energy of the motor is converted into electrical energy. The energy of the motor is thereby fed back into the supply of the stepper motor output stage; this then increases the supply voltage. It should be noted that the maximum supply voltage of 60 V cannot be exceeded! The external capacity of the motor supply is possibly needed, if the capacitors of the mains supply is insufficient or or an active ballast circuit converts the excess energy into heat.

Note: voltage ripple

To keep the voltage ripple within the allowable range (< 2 Vss), an electrolyte capacitor of the appropriate value must be connected in parallel to the motor supply terminals. As a reference value for the required capacitance, approximately 2000 µF per Ampere supply current can be assumed. To achieve optimal EMV ratio, it is recommended that the capacitor be mounted near the output stage of the stepper motor and the connection lines be as short as possible.

The connector at X6 cannot be inserted or removed during operation!

Voltage monitor

Power supply +24 V	Supply voltage > 18 V (DC OK-LED lights green)
Supply voltage Stepper motor	Supply voltage > 18 V and < 60 V (DC OK-LED lights green)

Miscellaneous

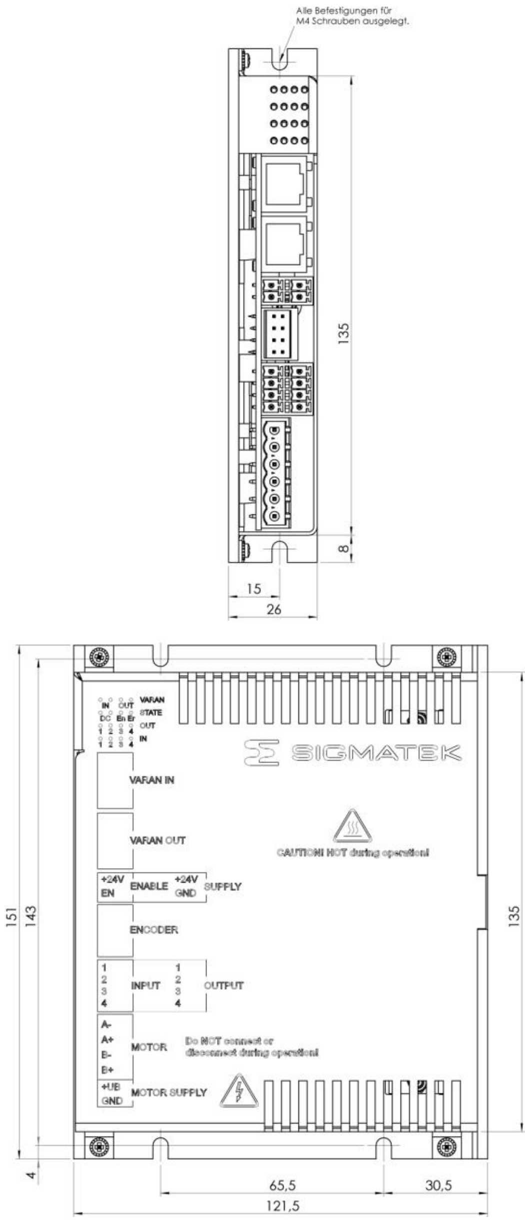
Article number	16-014-012
Hardware version	1.x
Approval	CE, cULus

Environmental conditions

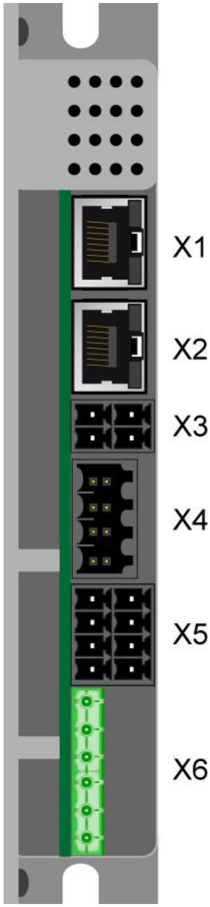
Storage temperature	-20 – +85 °C	
Environmental temperature	0 – +60 °C	
Humidity	0 - 95 %, non-condensing	
Operating conditions	Pollution degree 2	
EMV resistance	In accordance with EN 61000-6-2 (industrial area)	
EMC - noise generation	In accordance with EN 61000-6-4 (industrial area)	
Shock resistance	EN 60068-2-27	150 m/s²
Protection Type	EN 60529	IP 20

Please note:
The VST 012 does not have a motor temperature sensor.

Mechanical Dimensions

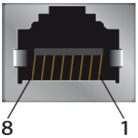


Connector Layout



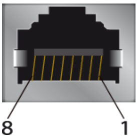
Connector Layout

X1: VARAN-In 8-pin RJ45



Pin	Function
1	TX+
2	TX-
3	RX+
4	n.c.
5	n.c.
6	RX-
7	n.c.
8	n.c.

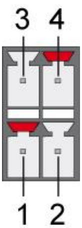
X2: VARAN Out (8-pinRJ45)



Pin	Function
1	TX+
2	TX-
3	RX+
4	n.c.
5	n.c.
6	RX-
7	n.c.
8	n.c.

n.c. = not connected

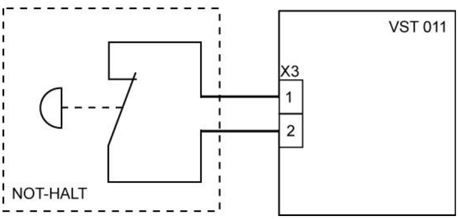
X3: +24 V supply, Enable



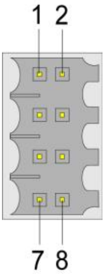
Pin	Function
1	+24 V for Enable
2	ENABLE
3	+24 V
4	GND

Note: Coding element on pin 1 and 4

Example of wiring for an Emergency Stop on the Enable input

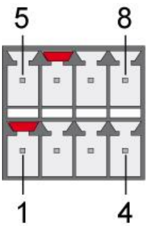


X4: Incremental encoder



Pin	Function
1	A-
2	A+
3	B-
4	B+
5	R-
6	R+
7	GND
8	+5 V encoder

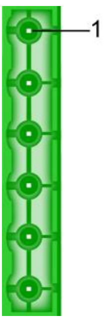
X5: Digital in and outputs



Pin	Function
1	Input 1
2	Input 2
3	Input 3
4	Input 4
5	Output 1
6	Output 2
7	Output 3
8	Output 4

Note: Coding element on pin 1 and 6

X6: Stepper Motor



Pin	Function
1	A-
2	A+
3	B-
4	B+
5	Motor voltage (18 – 60 V)
6	GND

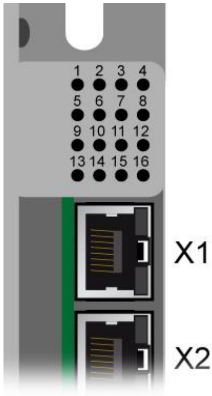
Applicable connectors

Connectors with spring terminals:

1 x 8-pin Weidmüller plug: B2L/B2CF 3,5/8
2 x 2-pin Phoenix Contact FMC1.5/2-ST-3.5
2 x 4-pin Phoenix Contact FMC1.5/4-ST-3.5
1 x 6-pin Phoenix Contact FKC2.5HC/6-ST-5.08

The complete VARAN VKL 131 connector set with spring terminals is available from Sigmatek under the article number 16-600-131.

Status Displays

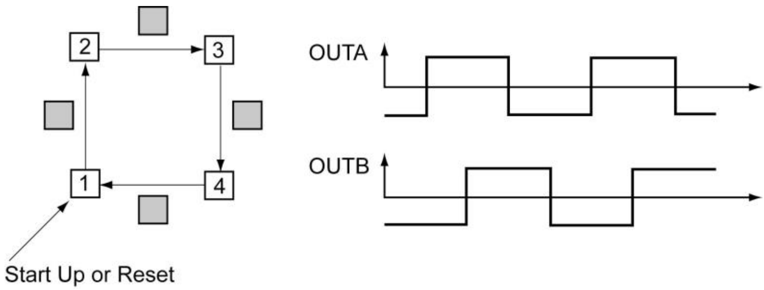


LED-Nr.	Assignment	Color	Function
1	VARAN-In Link	Green	Lights when the connection between the two PHYs is established
2	VARAN-In Active	Yellow	Lights when data is exchanged over the VARAN bus
3	VARAN-Out Link	Green	Lights when the connection between the two PHYs is established
4	VARAN-Out Active	Yellow	Lights when data is exchanged over the VARAN bus
5	24 V OK	Green	Lights when the supply voltage is available at X3 18 - 30 V
6	Motor voltage OK	Green	Lights when the motor voltage is available at X6 (18 - 60 V).
7	Motor Enable	Green	Lights when the output stage of the motor is released.
8	Error	Red	Lights when an error has occurred. - Motor supply < 18 V or > 60 V - +5 V I-encoder supply short - Motor output short - Motor temperature over 95°C
9	Output 1	Yellow	Lights when output 1 is activated.
10	Output 2	Yellow	Lights when output 2 is activated.
11	Output 3	Yellow	Lights when output 3 is activated.
12	Output 4	Yellow	Lights when output 4 is activated.
13	Input 1	Green	Lights when input 1 is high.
14	Input 2	Green	Lights when input 2 is high.
15	Input 3	Green	Lights when input 3 is high.
16	Input 4	Green	Lights when input 4 is high.

Operating Mode Options for Motor Control

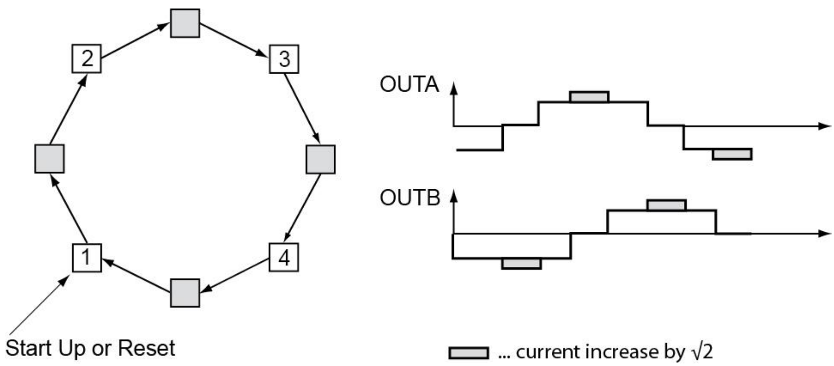
Full step mode

In full step mode, Current is applied to the winding as shown below. The motor rotates in full steps only. This means that in one turn the rated number of steps is taken.



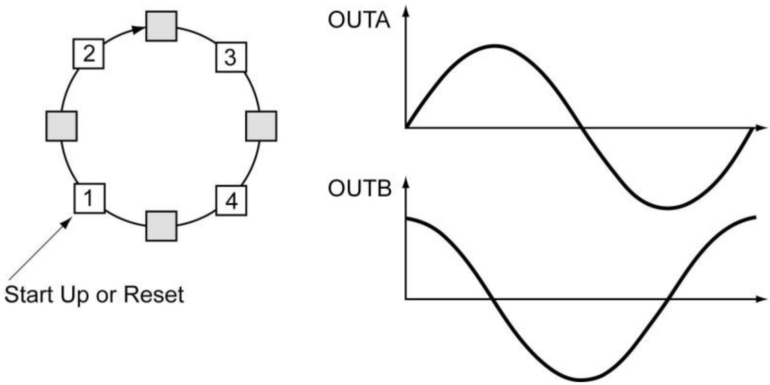
Half step mode

In half step mode, Current is applied to the winding as shown below. Between each full step, an intermediate step is taken. The resolution per turn is thereby doubled.
In half step mode, a current increase can be activated by the software to reach 95% of the full step torque.



Micro step mode

In micro step mode, a nearly sine wave formed current is applied to the individual windings. With the VST 012, the resolution of the sine oscillation is 128 steps. 32 micro steps per full step are thereby produced.



Stepper Motor Current Regulator

The current regulation for the stepper motor is influenced by the current rise and/or fall time in the motor windings. These times are critically dependent on the supply voltage level, inductivity and the resistance of the motor windings.

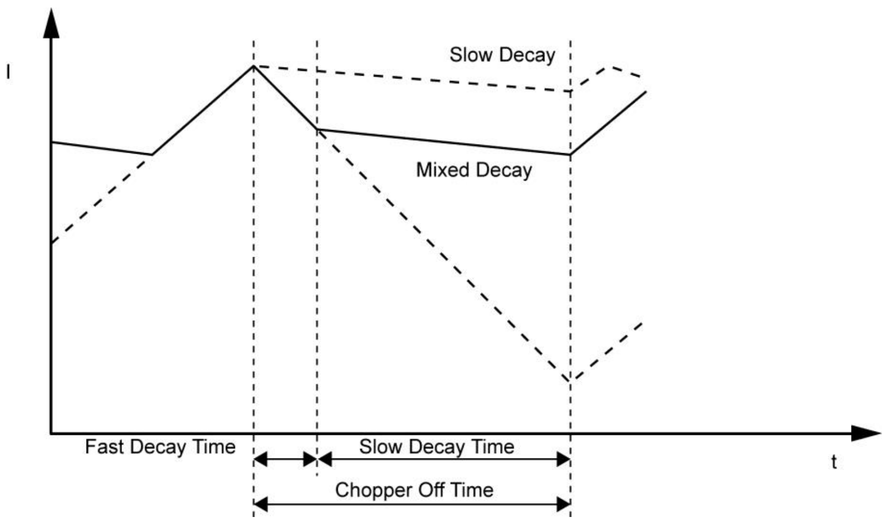
The current rise time can be influenced by the supply voltage level. The higher the supply voltage, the faster the motor winding current rises.

The current fall time in the motor windings can be influenced by the decay mode.

In slow decay mode, the motor windings are shorted over the H-bridge.
The energy stored in the windings is dissipated over the internal resistance of the motor and the H-bridge of the output stage.

In fast decay mode, the current sinks significantly faster since the windings are shorted by reversing the polarity. The energy stored in the windings is thereby fed back to the supply.

If both variants are used during reduction of the motor current, the motor is in mixed decay mode. In this mode, the advantages of both processes are unified. The current is first reduced to a threshold with fast decay and then switched to slow decay to keep the current ripple low.
The decay mode is defined by setting the "Chopper Off Time" and "Fast Decay Time" (Slow Decay Time = ChopperOffTime - FastDecayTime).

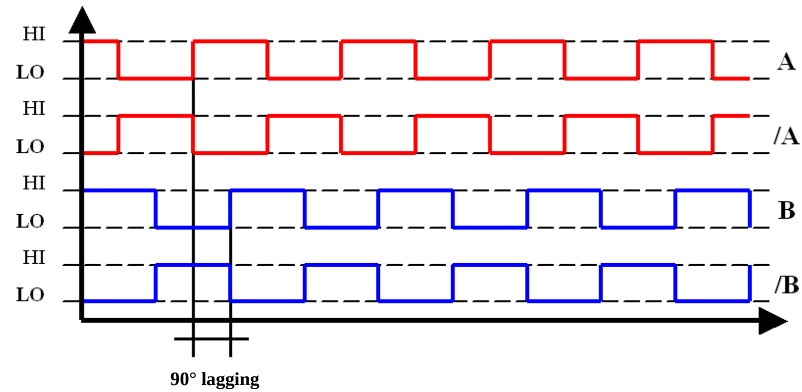


The current regulator functions so that the H-bridge actively energizes the motor windings until the value setting of the current is reached. Afterwards, the current reduction process (depending on the defined decay mode) is started.

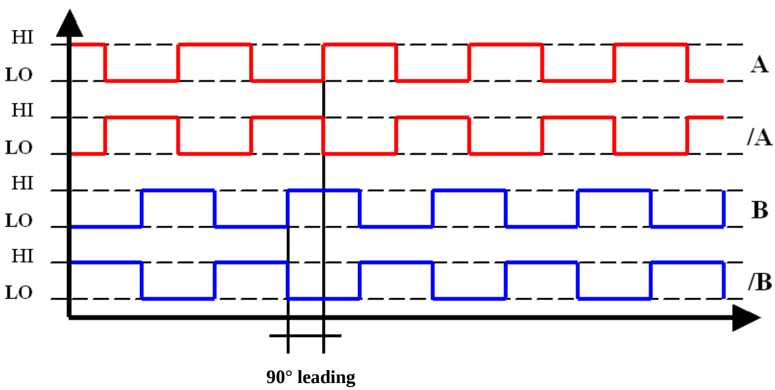
When the motor windings are switched over the H-bridge, parasitic capacitances always generate current spikes during charging/discharging. The current measurement for this time (blanking time) must be deactivated. The blanking time can be set in the software.

Incremental Encoder Signals

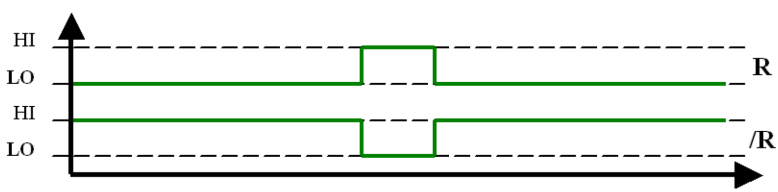
Count UP



Count DOWN



Reference pulse (zero position)



Mounting and Wiring Guidelines

To ensure error-free operation, careful mounting and wiring guidelines must be followed!

The following guidelines should be observed:

- The VST 012 housing must be mounted on the grounded metal mounting plate in the control cabinet to ensure the required cooling of the power component as well as the necessary connection to mass!

- To avoid the coupling of noise, the following wires must be properly shielded:
  - VARAN IN/OUT => see VARAN shielding recommendation
  - I-encoder
  - Motor

  It is recommended that the shielding be applied before the component group in the control cabinet!

- The parallel wiring of signals lines with load current circuits should be avoided!

- General Information on the Digital Outputs:

  The 4 outputs are powered by a common +24 V supply (X3).

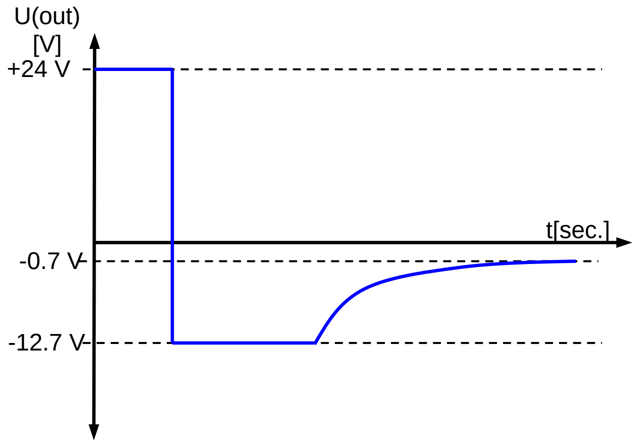
  The cross section of the +24 V and 0 V supply must be designed for the maximum output current drawn by a group.

  Applying power to an output whose supply voltage exceeds 0.7 V is not allowed.

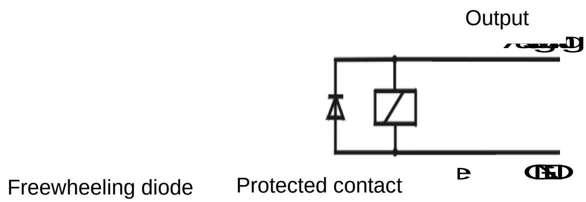
  Each group of 4 outputs is also protected internally against +24. Braking of inductive loads is limited to – 12.7 V as shown in the graph below. However, an additional protection circuit directly on inductive loads is recommended (freewheeling diode) to avoid a system failure caused by voltage spikes (cross talk on analog lines). However, this results in the internal voltage limit being effective up to -0.7 V only.

- Use 60/75 °C copper wires only!

Disconnecting inductive loads:



Connecting inductive loads:



Recommended Shielding for VARAN

The VARAN real-time Ethernet bus system exhibits a very robust quality in harsh industrial environments. Through the use of IEEE 802.3 standard Ethernet physics, the potentials between an Ethernet line and sending/receiving components are separated. In the event of an error, the VARAN Manager resends messages to a bus participant immediately. The shielding described below is principally recommended.

For applications in which the bus is run outside the control cabinet, the correct shielding is required. This is especially important, if due to physical requirements, the bus cables must be placed next to sources of strong electromagnetic noise. It is recommended to avoid placing VARAN bus lines parallel to power cables whenever possible.

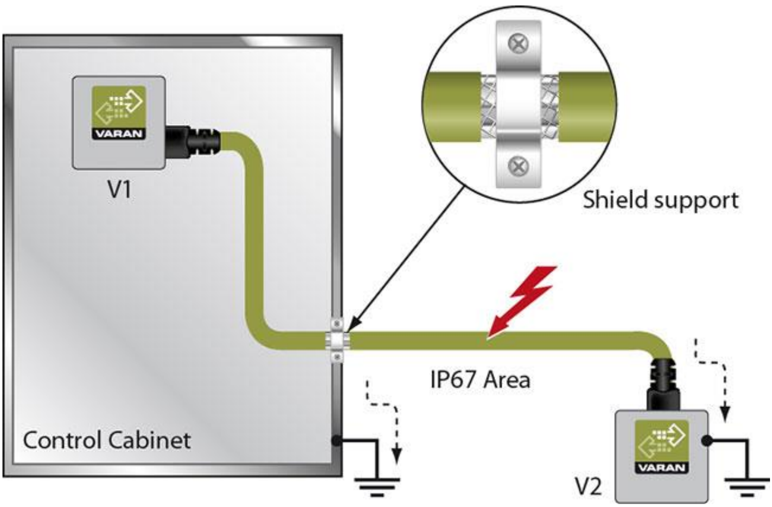
SIGMATEK recommends the use of CAT5e industrial Ethernet bus cables.

For the shielding, an S-FTP cable should be used. An S-FTP bus is a symmetric, multi-wire cable with unshielded pairs. For the total shielding, a combination of foil and braiding is used. A non-laminated variant is recommended.

The VARAN cable must be secured at a distance of 20 cm from the connector for protection against vibration!

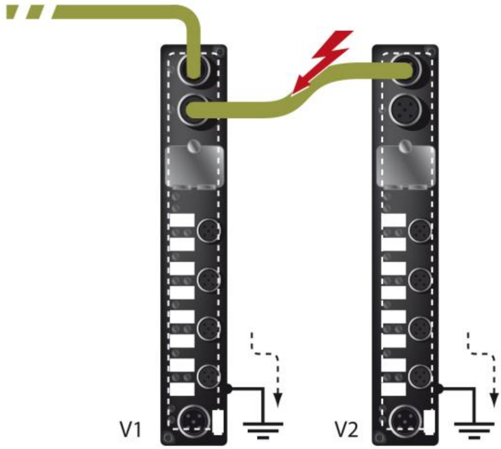
Wiring from the Control Cabinet to an External VARAN Component

If the Ethernet lines are connected from a VARAN component to a VARAN node located outside the control cabinet, the shielding should be placed at the entry point to the control cabinet housing. All noise can then be deflected from the electronic components before reaching the module.



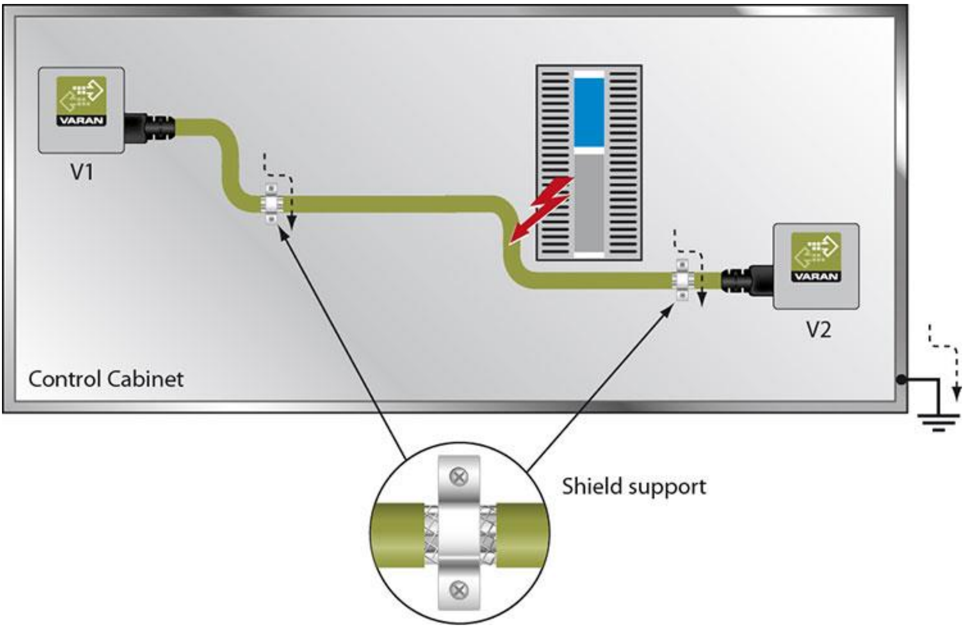
2. Wiring Outside of the Control Cabinet

If a VARAN bus cable must be placed outside of the control cabinet only, no additional shield connection is required. This requires that only IP67 modules and connectors be used. These components are very robust and noise resistant. The shielding for all sockets in IP67 modules are internally connected to common bus or electrically connected to the housing, whereby the deflection of voltage spikes does not flow through the electronics.



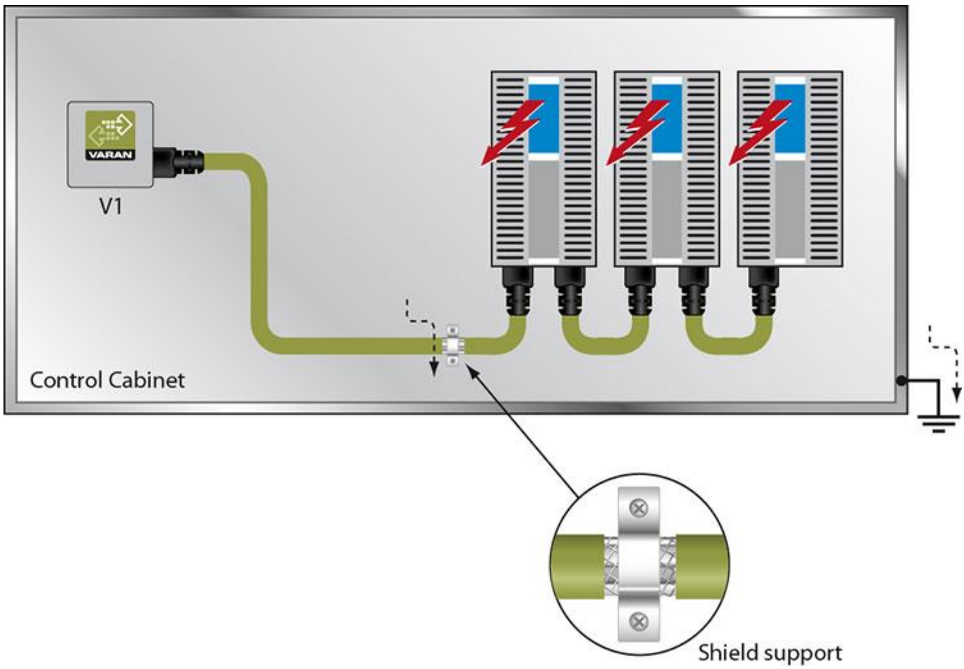
3. Shielding for Wiring Within the Control Cabinet

With sources of strong electromagnetic noise with the control cabinet (drives, transformers and similar), noise can be induced in a VARAN bus line. Spike voltages are deflected over the metallic housing of a RJ45 connector. Noise is conducted through the control cabinet housing without further action from the electronic components. To eliminate sources of noise during data transfer, it is recommended that the shielding for all electronic components be connected within the control cabinet.



4. Connecting Noise-Generating Components

With the connection of power components, which generate strong electromagnetic interference, it is also critical to ensure correct shielding. The shielding should be placed before a power element (or group of power elements).



5. Shielding Between Two Control Cabinets

If two control cabinets must be connected over a VARAN bus, it is recommended that the shielding be located at the entry points of both cabinets. Noise can be thereby stopped from reaching the electronics within the control cabinet.