

Vineyards

Frost Protection

Application guide

DEVI[®]
by Danfoss

Make it easy,
make it DEVI



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Our quality management system **certifications** and **compliances**



Along with full compliance with EU directives and product approvals

Solve the challenge of vine growers with an Electric Heating system

Electric Heating by Danfoss is a symbiosis of long history formed by 2 brands DEVI and Danfoss united under 1 company umbrella.

It derives from DEVI brand that was established in Copenhagen, Denmark, in 1942. As from January 1st 2003 DEVI has become a part of the Danfoss Group - Denmark's largest industrial Group.

Danfoss is one of the world's leading companies within heating, cooling and air conditioning. The Danfoss Group has more than 23.000 employees and serves customers in more than 100 countries. The development of electric heating systems takes place in Denmark, where the head office is situated while heating elements (cables and mats) are manufactured by Danfoss in EU.

Electric Heating is an energy efficient system using electric heating cables to protect vines against frost damage.

This design guide presents our recommendations for design and installation of Vineyards Frost Protection system. It provides guidance for a heating cable layout, electric data and system configurations.

Following our recommendations will ensure energy efficient, reliable and maintenance free solution for constant wattage heating cables with 20 year warranty.

1. Application overview

Every year vine growers from different regions face a problem of late frosts. They often happen in April - May when buds start blossoming. At night, when the ground cools quickly, the heavier, cold air flows down the slopes and collects in the low-lying areas, forming a "cold air lake." Due to the lack of wind to mix the air, the temperature in the valleys becomes lower than on the surrounding slopes, leading to frost.

Late spring frosts are one of the greatest challenges vine growers are facing. Non-heated vines can suffer considerable inflorescence damages (up to 50%), whilst heated vines will have dramatically improved protection of harvest loss or damage and reduce the losses to approximately 13-20%.

Worldwide, the grape and wine industry rely on three main alternatives for frost protection: frost fans, sprinklers, and candles.

Electric Heating solves the challenge with energy efficient systems using Electric Heating cables to protect vines against frost damage.

A green (without CO₂ emissions) and sustainable lifetime solution. Highly economic due to low energy consumption during the frosts period.

- Protected against chemical fertilizers;
- Extremely-high pulling strength (special tractors toward the vineyards, while knocking the fruits);

Benefits

- An energy-efficient solution with electric heating cables.
- Easy, fast and reliable installation.
- A customized approach to meet client's needs, area of vineyard and number of rows.
- Proven high saving compared to the existing methods.
- A sustainable solution for a green and clean future through low energy consumption during the frost period.
- Tough cable outer sheath (resistant to weather and UV)



- Accurate power design (W) according to requested needs;
- 5 or 20 years warranty.

Heating system can provide frost protection ONLY in spring season when the bud grows and NOT in wintertime!

2. System description

Electric Heating solves the challenge with energy efficient systems using Electric Heating cables to protect vines against spring frost damage. The heating cables by DEVI are installed and fixed on metal wire along the grapes. The system is controlled automatically by temperature sensors connected to the controller.

Non-heated vines can suffer considerable inflorescence (bud) losses. Number of berries can decrease by 3 times or completely disappear!

Different grape varieties can withstand frosts different.

A dormant bud is reasonably frost hardy, it can survive frost down to $-3,5\text{ }^{\circ}\text{C}$ (Pinot Noir).

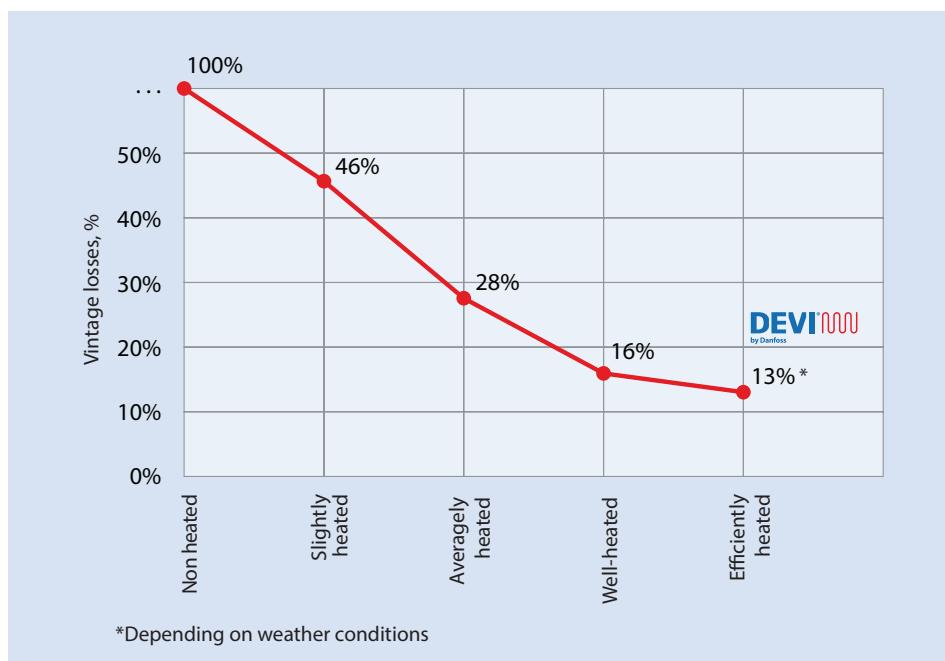
As the bud grows the water contents raise in the bud and it becomes more susceptible to frost $-1,1\text{ }^{\circ}\text{C}$ can damage it (Pinot Noir).

We offer an energy-efficient solution with our electric heating cables for frost protection of the vines.

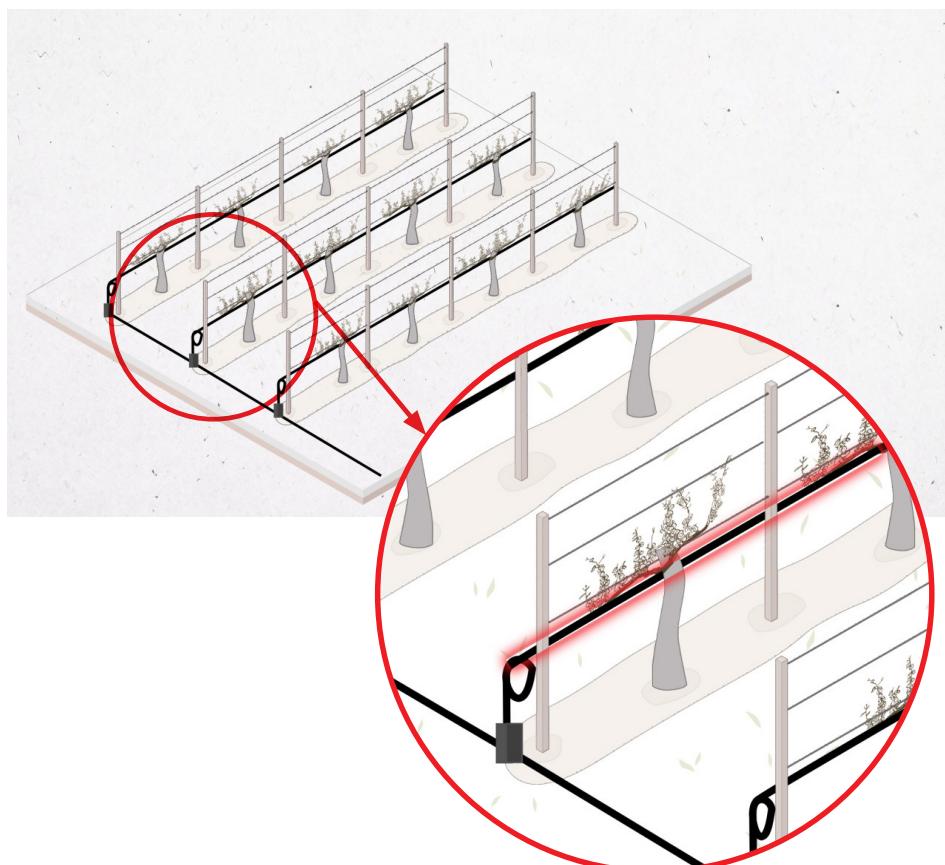
The concept involves installation of heating cable along the main trellising wire of grapevines.

- Frost protection in spring time (from 2 up to 7 days)
- The ambient temperature is $-2\text{...}-8\text{ }^{\circ}\text{C}$
- Most susceptible to frost vineyards are located in the lowlands/valleys (low area of land)

Depending on heating level, vintage losses may be decreased



Common view of electric heating system for vineyards



3. System design

Following pages provide an easy design guide for selection of a Vineyards frost protection system. The recommendations are provided relates to heating cables, as well as thermostats and accessories.

3.1 Heat loss calculation

Linear output of a heating cable (W/m), which is installed for main vine branch, should be at least the same as heat loss (Q, W/m).

In order to calculate heat losses and design the system, we need to know:

- Minimum ambient temperature in spring frost period (**-2...-8 °C**);
- Grape sort. For different sorts we need to maintain different temperature (**+1...+5 °C**). The temperature must be checked with vineyard owner and specified for the project calculation;
- Length and numbers of vineyard rows;
- Available total load on site, kW;
- Voltage (230, 400 V).

For **medium weather conditions***, in order to increase temperature by **1 °C** needs power of approx. **1,7 Watt**. In average

can be installed from **15 up to 20 W/m** for each main branch of grapevine.

Example

Location is France and ambient temperature during frosts period is -8 °C. Grape sort is Pinot Noir and we can maintain +2 °C near the main vine branch.

According to the data above:

$$q_{sys} = \Delta t_{main.-amb.} \cdot p$$

$$\Delta t_{main.-amb.} = t_{main.} - t_{amb.} = +2 - (-8) = 10 \text{ °C}$$

$$q_{sys} = 10 \cdot 1,7 = 17 \text{ W/m}$$

q_{sys} – heat loss of the system, W/m.

$t_{main.}$ – maintain temperature near the vines, °C.

$t_{amb.}$ – ambient temperature, °C.

p^{**} – output coefficient, W/(m · °C).



* Medium conditions are the following: wind velocity is from 1-3 m/s. But it always depends on local weather conditions!

** Note that values in the table above are calculated without influence of altitude, Nusselt and Prandtl criterions.

For more info: EH@danfoss.com

3.2 System output

The heat required for vineyards frost protection depends on the following main factors:

- Weather conditions (min. temperature, wind speed, humidity, altitude)
- Electrical data (voltage, power, control requirements)
- System performance expectations
- Safety factor

With data from previous example will calculate linear output of heating cable:

$$p_{sys} = q_{sys} \cdot 1,3$$

$$p_{sys} = 17 \cdot 1,3 = 22,1 \text{ W/m}$$

However, in some locations the **wind is present** at any time of the day. In such cases we need to add influences of wind velocity.

Heat transfer coefficient should be considered according to wind velocity.

Safety factor is very important and depends on the following parameters:

- Tolerance of heating cable resistance: +10%...-5%;
- Cable length tolerance: +2%...-2%;
- Supply voltage: +5%...-5%.

Totally can be up to 30%

Wind velocity	2 m/s	3 m/s	4 m/s
Linear output*	15,5 W/m	22,1 W/m	24,5 W/m

Total system output depends on numbers and length of vine rows and should be calculated in order to choose appropriate load equipment.

$$P_{tot} = p_{sys} \cdot n \cdot L_r$$

$$P_{tot} = 22,1 \cdot 10 \cdot 100 = 22100 \text{ Watts}$$

P_{tot} – total output of the system, W;

p_{sys} – linear output of the system, W/m;

n – vine row numbers;

L_r – vine rows length, m.

4. Product selection

This section will show how to choose the correct heating element, control device and what accessories to use for the installation.

The electric heating system product portfolio for the Vineyards Frost protection consists of three major components:

- Heating element – heating cable with constant wattage ready-made units or drum goods;
- Controller with a temperature sensor or a controller with both temperature and moisture sensors;

- Fixing elements and accessories.

DEVI frost protection systems can be fully automated which eliminates the need for field personnel during frost events.

Also, the prefabricated cold connections in DEVI factories offer considerable time savings in the deployment of frost protection systems. Connection to the electrical cabinet is pretty easy due to DIN rail construction.



4.1 Heating cable selection

Most of cables are manufactured as ready-made heating elements with a specific length, with connecting power supply cable (cold lead or cold tail) and sealed joints (connection muffs or end terminals).

It is also possible to choose special drum goods which can be customized for the specific project.

Main rules how to choose suitable heating cable:

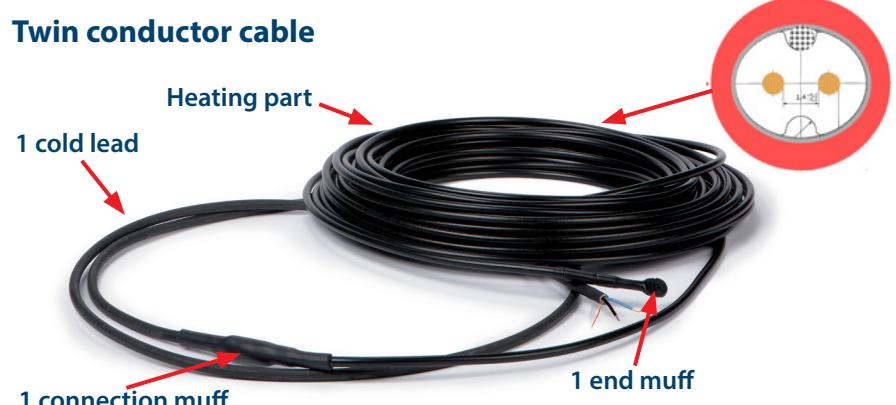
- Calculate heat loss;
- Add safety factor to heat loss (usually + 30% or 1,3);
- Outer sheath of heating cable MUST be UV protected;
- Check voltage supply and choose suitable heating cable: 230 V or 400 V;

- Choose product type: ready-made units or drum goods (usually depends on specific row length and linear output).

Range of the heating cables linear output for vineyards frost protection is usually between 15 and 20 W/m (Watt per linear meter).

4.1.1 Ready-made heating cables

The heating cable offered for the application is constant wattage cable with an extremely high-quality. Its round profile and robust construction ensures a fast, simple and safe installation in multiple applications.



Product	Linear output, W/m	Type	Max. permissible use temp., °C	Cable dimensions, mm	Conductor insulation	Outer sheath	Cold lead	IP class
DEVIsafe™ 20T	20	Twin conductor	60	6,9	XLPE	PVC UV protected	One 2,3 m DTCL	IPX7
DEVIsnow™ 20T	20	Twin conductor	70	7	FEP	PVC UV protected	One 2,3/10/30 m DTCL	IPX7

4.1.2 Drum goods

- Not ready-made cables, only heating part;
- shielded/screened cables;
- MUST be done separate calculation depending on cable length, linear output, voltage, ohmic value before offering the cables to customers;
- **please use calculation tool or contact local sales representative or EH@danfoss.com.**

Drum goods can be customized for the specific project depending on voltage, required output, length of heating cable and length of cold leads.

Cable calculation formulas:

$$L = U / \sqrt{p \cdot r}$$

$$r = U^2 / (L^2 \cdot p)$$

$$p = U^2 / (L^2 \cdot r)$$

where:

L – length of heating cable (m);

U – supply voltage (V);

p – linear output (W/m);

r – linear resistance (Ohm/m).



Product	Linear output, W/m	Type	Max. permissible use temp., °C	Cable dimensions, mm	Conductor insulation	Outer sheath	Cold lead	IP class
DEVIprotect™ Drum Goods	Separate calculation	Twin conductor	60	7	FEP	PVC UV protected	No	IPX7

Note: It is the full responsibility of the installer/designer to use proper cold lead dimensioned for the purpose and assembly sets that establish sufficient mechanical strength, flammability resistance and water tightness - and to design the heating unit with correct output for the specific application to avoid overheating of the cable or building materials.

To ensure a long life-time, all cables are minutely inspected including tests for Ohmic resistance, high voltage and material controls to ensure the quality.

Possible solutions for drum goods are already presented in the table below. Cable lengths depend on ambient temperature, linear output and voltage. Always contact technical department

in order to check your own calculations.

How to use the table below?

Based on known minimum protected temperature, linear output of the cable, voltage and resistance, the actual length of the cable can be found (and opposite):

1. Find minimum protected temperature in the top bar of the table (e.g. -4 °C);

2. Choose suitable linear output of the cable based on heat loss calculation (e.g. 16 W/m);
3. Find suitable voltage (e.g. 400 V);
4. Choose resistance value (e.g. 1,519 Ohm/m);
5. Follow the vertical and horizontal lines, until they meet.

Description	Resistance	Minimum protected temperature															
		-3°C		-4°C ①		-5°C		-6°C		-7°C		-8°C		-9°C		-10°C	
		Cable length		Cable length		Cable length		Cable length		Cable length		Cable length		Cable length		Cable length	
		at 15 W/m (-3°C)		at 16 W/m (-4°C) ②		at 17 W/m (-5°C)		at 18 W/m (-6°C)		at 19 W/m (-7°C)		at 20 W/m (-8°C)		at 21 W/m (-9°C)		at 22 W/m (-10°C)	
		230 V	400 V	230 V	400 V ③	230 V	400 V	230 V	400 V								
DEVprotect 9,36 ohm/m	9.36	19.4	33.8	18.8	32.7	18.2	31.7	17.7	30.8	17.2	30.0	16.8	29.2	16.4	28.5	16.0	27.9
DEVprotect 4,19 ohm/m	4.19	29.0	50.5	28.1	48.9	27.3	47.4	26.5	46.1	25.8	44.8	25.1	43.7	24.5	42.6	24.0	41.7
DEVprotect 2,368 ohm/m	2.368	38.6	67.1	37.4	65.0	36.3	63.0	35.2	61.3	34.3	59.6	33.4	58.1	32.6	56.7	31.9	55.4
DEVprotect 1,519 ohm/m	④ 1.519	48.2	83.8	46.7	81.1	45.3	78.7	44.0	76.5	42.8	74.5	41.7	72.6	40.7	70.8	39.8	69.2
DEVprotect 1,057 ohm/m	1.057	57.8	100.5	55.9	97.3	54.3	94.4	52.7	91.7	51.3	89.3	50.0	87.0	48.8	84.9	47.7	82.9
DEVprotect 0,735 ohm/m	0.735	69.3	120.5	67.1	116.6	65.1	113.2	63.2	110.0	61.5	107.0	60.0	104.3	58.5	101.8	57.2	99.5
DEVprotect 0,567 ohm/m	0.567	78.9	137.2	76.4	132.8	74.1	128.8	72.0	125.2	70.1	121.9	68.3	118.8	66.7	115.9	65.1	113.3
DEVprotect 0,451 ohm/m	0.451	88.4	153.8	85.6	148.9	83.1	144.5	80.7	140.4	78.6	136.6	76.6	133.2	74.7	130.0	73.0	127.0
DEVprotect 0,367 ohm/m	0.367	98.0	170.5	94.9	165.1	92.1	160.1	89.5	155.6	87.1	151.5	84.9	147.6	82.8	144.1	80.9	140.8
DEVprotect 0,257 ohm/m	0.257	117.1	203.7	113.4	197.3	110.0	191.4	106.9	186.0	104.1	181.0	101.4	176.4	99.0	172.2	96.7	168.2
DEVprotect 0,19 ohm/m	0.19	136.2	236.9	131.9	229.4	128.0	222.6	124.4	216.3	121.1	210.5	118.0	205.2	115.1	200.3	112.5	195.6
DEVprotect 0,146 ohm/m	0.146	155.4	270.3	150.5	261.7	146.0	253.9	141.9	246.7	138.1	240.2	134.6	234.1	131.4	228.4	128.3	223.2
DEVprotect 0,115 ohm/m	0.115	175.1	304.6	169.6	294.9	164.5	286.1	159.9	278.0	155.6	270.6	151.7	263.8	148.0	257.4	144.6	251.5
DEVprotect 0,092 ohm/m	0.092	195.8	340.5	189.6	329.7	183.9	319.8	178.7	310.8	174.0	302.5	169.6	294.9	165.5	287.8	161.7	281.2
DEVprotect 0,07 ohm/m	0.07	224.5	390.4	217.3	378.0	210.8	366.7	204.9	356.3	199.4	346.8	194.4	338.1	189.7	329.9	185.3	322.3
DEVprotect 0,055 ohm/m	0.055	253.2	440.4	245.2	426.4	237.9	413.7	231.2	402.0	225.0	391.3	219.3	381.4	214.0	372.2	209.1	363.6

Table can be used in opposite way where, based on length, voltage and linear output, a suitable cable from the product range can be found.

4.2 Thermostats/controllers

Thermostats and controllers are fitted with a complete set of control functions for frost protection systems. It is a combination of multi functionality and temperature control.

The product range of controls is designed for frost protection systems including the following:

- **simple electronic thermostats;**
- **digital controllers.**

Line of **simple electronic thermostats** to be installed in electric cabinets with DIN rail attachment. To measure and control the desired temperature either a wire sensor (in the set) or an external indoor/outdoor air sensor must be used. The thermostat must be installed via an all-pole disconnec-

tion switch. It has a LED indicating showing standby (green light) and heating (red light) periods.

To control simple or low output (less than 3000 Watts) systems, simple thermostats are recommended as a standard solution.

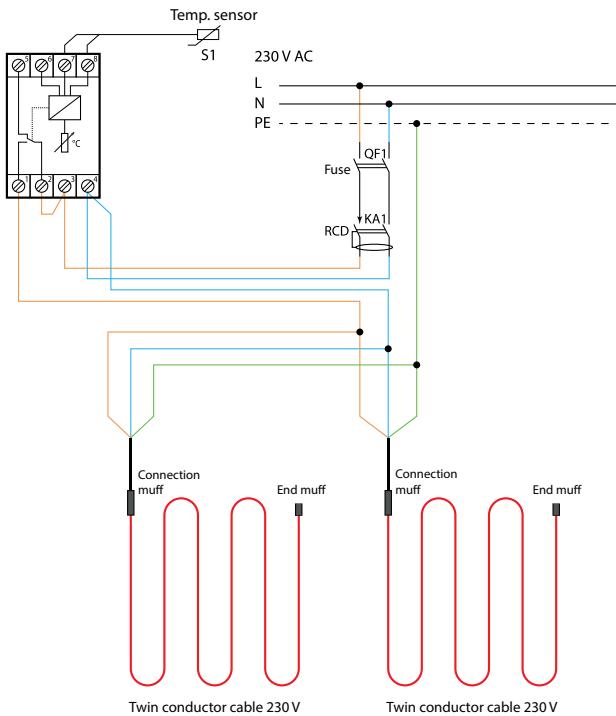
DEVIREG™ 330 (+5...+45 °C) and DEVIREG™ 330 (-10...+10 °C) can be used for such purposes.

Wire sensors should be installed according to specific project data. Minimum one sensor must be used for one heated zone (could be one vineyard row or few rows depending on field size and location). Always contact local sales representative or **EH@danfoss.com** in order to get technical help.

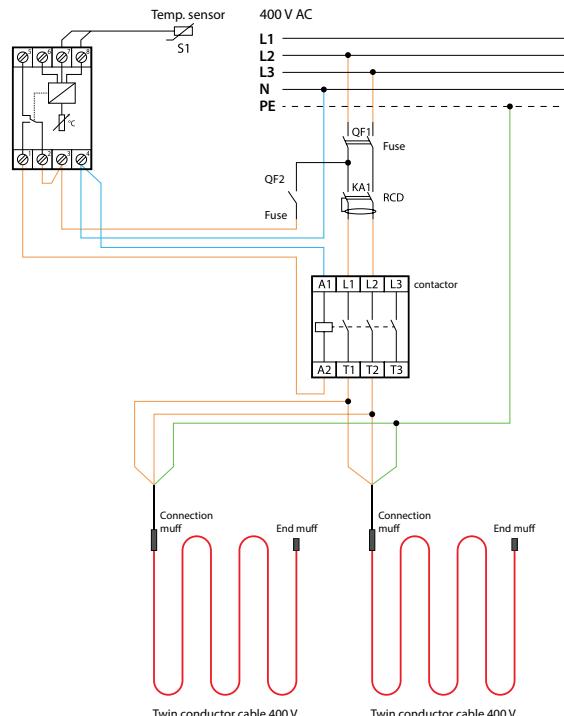


Find basic thermostat connections below.

Thermostat connection of twin conductor heating cables (max. 3680 Watts at 230 V).



Thermostats connections of twin conductor heating cables (400 V) via contactor.



For more connection schemes please contact EH@danfoss.com.

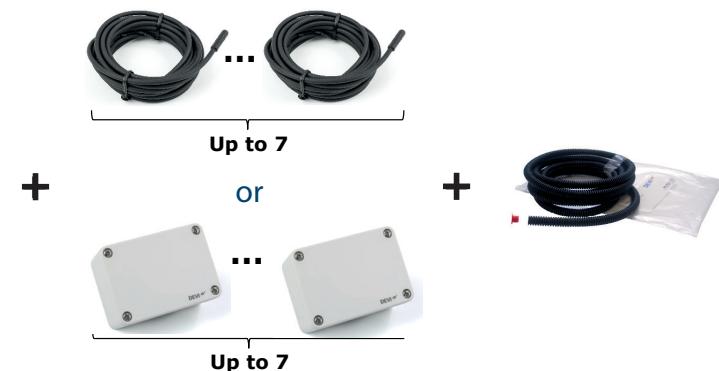
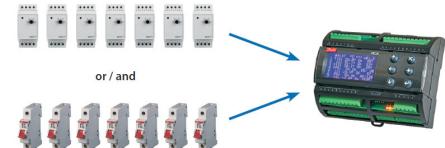
Line of **digital controllers** have special functions which can be programmed for different purposes.

DEVIreg™ Multi is 7 channel electronic programmable controller to be installed on DIN rail.

Every channel can be individually set up with three control modes – with temperature sensor, time proportional power regulation without sensor and manually on/off with time limitation.

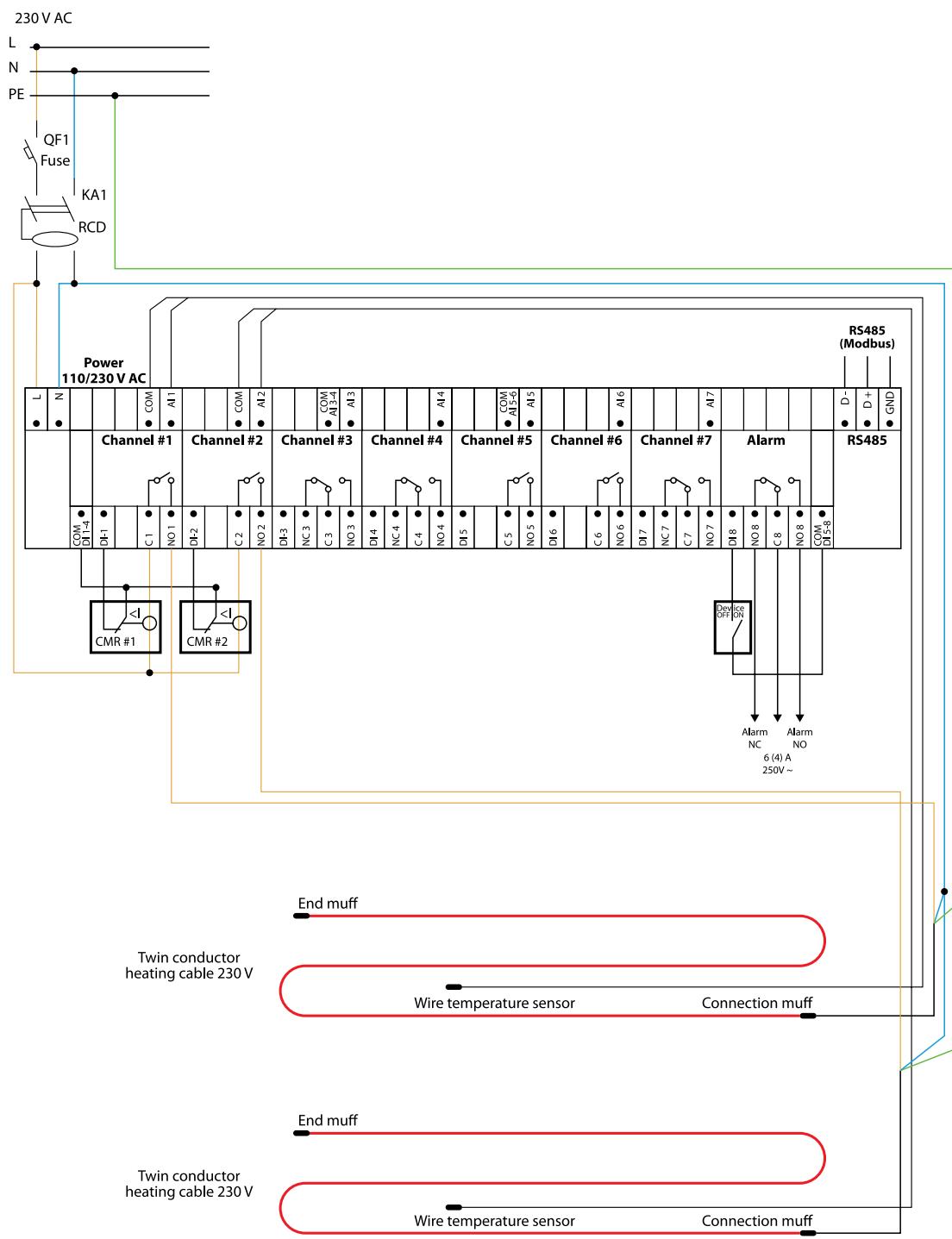
Main functions of it are next:

- 3 control modes:
 - with temperature sensor
 - time proportional regulation
 - manual On/Off with time limitation
- 7 channel controller;
- DIN rail;
- Modbus interface for BMS control;
- Cable failure monitoring (alarm);
- The wide temp range.



Find basic thermostat connections below.

Thermostat connection of twin conductor heating cables (230 V).



For more connection schemes please contact EH@danfoss.com.

Product	Resistive load, at 230V, Amps	Sensor type	Temperature range, °C	Hysteresis, °C	BMS	IP class	Installation
DEVireg™ 330 (-10...+10 °C)	16	Wire	-10...+10	±0,2	No	IP20	DIN rail
DEVireg™ 330 (+5...+45 °C)	16	Wire/Air optional	+5...+45	±0,2	No	IP20	DIN rail
DEVireg™ Multi	10 (2 channels) 6 (5 channels)	Wire/Air optional	-50....+200	±0,2...9	Yes	IP40	DIN rail

4.3 Accessories

DEVI product range has all necessary accessories for fixing, measurement and connection

in order to provide full project specification.

In order to find all accessories please refer to Product Catalogue or visit www.devi.com

<p>Cable ties</p>  <p>Plastic ties for fixing heating cables</p>	<p>Wire sensors</p>  <p>Wire sensors for different temperature range</p>	<p>Air sensor</p>  <p>Outdoor air sensor with IP44</p>
<p>Plastic conduit pipe</p>  <p>Plastic conduit pipe for wire sensors</p>	<p>DTCL Cold leads</p>  <p>Different cold leads with different cross sections and construction are available for ordering</p>	<p>End termination repair set</p>  <p>DEVICrimp™ CS-2C assembly kit dk 2-cond.</p>
<p>Heating cable to cold lead repair set</p>  <p>DEVICrimp™ for DEVIsnow™</p>	<p>Heating cable to heating cable repair set</p>  <p>DEVICrimp™ ass/repair kit 2-cond. CS-2A/CS-2B</p>	<p>Heating cable to cold lead/ heating cable repair set</p>  <p>Repair kit cables 2 cond. Concrete/støbesæt</p>

Note: always use only authorized accessories from DEVI!
For more details please use Product Catalogue or EH@danfoss.com.

5. Installation tips

After product selection proper installation should be done. Always use the following rules during the installation process:

- Heating cable should be installed on metal wire near the main branch of grapevines, the closer the cable is to the buds the more heat it will exert on the buds;
- One cable line for one row of vineyard. All cables should be connected in parallel;

- Heating cable can be fixed by UV resistant plastic tiles;
- Distance between cable and vines branch is maximum 0-2 cm;
- Control system should have temperature sensors (wire sensors);
- Install sensors where the temperature is estimated to be representative for the whole installation, where 2 sensors are needed for the thermostat/

controller please install at the estimated extreme points (coldest and hottest);

- Wire sensors should be installed in plastic conduit pipe (avoid direct contact of sun rays) near the main branch of grapevines;
- Alarm should be installed in order to check all cables which can be damaged by grape secateurs, tractors, etc.

1. Fix one line of the heating cable to metal wire by UV resistant plastic tiles. The main wine branch can be wrapped around the heating cable.



2. Heating cables should be connected to thermostat/controller according to local norms and regulations.

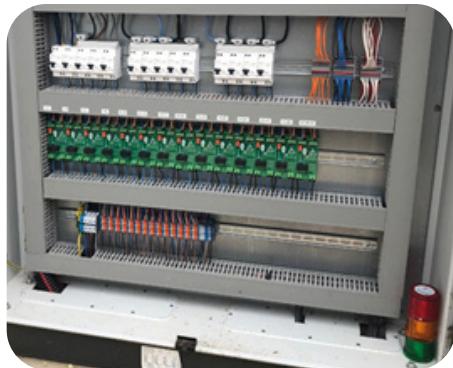
Contact EH@danfoss.com for all technical information about connections.



3. Install wire sensor in plastic conduit pipe and place it in coldest place near main branch of grapevines.



4. It is strongly recommended to install alarm system in order to check the integrity of the cables in real-time and before the frost season



As a result you will get reliable frost protection heating system providing a stable harvest.



6. Safety instruction

Heating cables must always be installed according to local regulations and wiring rules as well as the guidelines in this installation manual.

De-energize all power circuits before installation and service.

Residual current device (RCD) protection is required. RCD trip rating is max.30 mA.

The screen from each heating cable must be connected to

earthing terminal in accordance with local electricity regulations.

Heating cables must be connected via a switch providing all pole disconnection.

The heating cable must be equipped with a correctly sized fuse or circuit breaker according to local regulations.

Never exceed the maximum heat density (W/m or W/m²) for the actual application.

It is strongly recommended to

use the heating cable together with an appropriate thermostat to secure against overheating.

The presence of a heating cable must be made evident by affixing caution signs in the fuse box and in the distribution board or markings at the power connection fittings and/or frequently along the circuit line where clearly visible (tracing) must be stated in any electrical documentation following the installation.

6.1 DO's

- For installation of cable and thermostat/controller, always refer to the local regulations/legislations and respective manuals;
- Remember to fill out the warranty certificate with the required information as this will not be valid otherwise;
- Carefully complete the installation, the cable can break when overloaded;
- If any doubt arises consult you manual or local DEVI department;
- Ensure that the cable is sufficiently fixed and mounted according to the manual;
- Ensure that warning labels and stickers (potentially tape) with warning text is used to inform about the heat traced cable;
- Install sensors where the temperature is estimated to be representative for the whole installation, where 2 sensors are needed for the thermostat/controller please install at the estimated extreme points (coldest and hottest);
- To get the best performance of the system and avoid failures it is necessary to follow the installation descriptions;
- To get the best performance of the system it is strictly necessary to calculate the correct heat losses. Using this knowledge the cable with right output can be chosen;
- Plan every installation step and fixing point of the frost protection system ahead of time and ensure that the "run" is proper and possible;
- Ensure sensors are connected according to the applicable installation guide and/or application guide.

6.2 DON'Ts

- Never make an installation without thermostat/controller;
- Never install cables where the heat can't be dissipated, even with a self-limiting cable the output will never become zero and the cable can overheat;
- Never let unauthorized personnel install controllers/thermostats or heating elements;
- Never use unauthorized accessories;
- Never use our products (cables, controllers, sensors, etc.) outside provided temperature range.

7. Case stories

Please use the following link and QR code to find relevant case stories.



<https://devi.com/en/about-devi/case-stories>

8. Technical support

The Electric Heating team is offering valuable support to professionals when it comes to preparing your new projects.

We offer support for:

- Calculation of Electric Heating system;
- Development of drawings for projects;
- Preparation of the BoM (Bill of Material);
- Recommendations for the installation and operation of the system;
- Technical trainings.

In order to clarify the project data for different applications use the following technical request forms, fill in with your specifications and send it to:

EH@danfoss.com



<https://devi.com/en/service-and-support/global-technical-support>



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Make it easy,
make it DEVI

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Any information, including, but not limited to information on selection of product, its application or use, product design, weight, dimensions, capacity or any other technical data in product manuals, catalogues descriptions, advertisements, etc. and whether made available in writing, orally, electronically, online or via download, shall be considered informative, and is only binding if and to the extent, explicit reference is made in a quotation or order confirmation. Danfoss cannot accept any responsibility for possible errors in catalogues, brochures, videos and other material. Danfoss reserves the right to alter its products without notice. This also applies to products ordered but not delivered provided that such alterations can be made without changes to form, fit or function of the product.

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