Sufficient Voltage at the End of Long Cables.

Michael Raspotnig

The sheer size of systems such as printing machines, conveyor belts, steel rolling mills or bottling plants require long cables connecting the individual electrical machinery and system parts.

Data can be transmitted over long distances without problem. However, the same cannot be said about power for 24V devices. Severe voltage drops can occur if the wires are not sized properly. These voltage drops are often underestimated and can cause control components to fail or trigger a reset. Devices seldom draw current evenly. For example temporary voltage fluctuations can occur when a motor is connected and draws a high starting current so analyzing the causes of the failure is therefore much harder. We get similar effects when connecting loads with large input capacities.

In this case one solution is to connect a DC/DC converter as a "24 volt refresher" upstream of the load which generates a regulated 24V voltage to compensate for the fluctuation. DC-UPS's or buffer modules are ineffective in this situation.

Decentralized power supplies
Locating the power supply unit close to the device is one remedy as the drop at the 230V or 400V end is negligible due to the lower current. This would also counteract the general trend for decentralization.
However, 24V power supply units for control circuits are generally still loca-

ted in a central control cabinet. One reason is the desire to not have a dangerous voltage of 230V or 400V in decentralized control cabinets or machinery parts. Another reason is reducing the number of power supply units. It is simpler to adapt to the mains power supply with one central, standardized 24V power supply, depending on the country.

Calculating the voltage drops across wires.

Wire cross-sections (size) are selected according to taste or taken from charts which recommend a cross section according to the ampere value. These chart values are generally optimized to the admissible cable heating, not to the voltage drop. Undersized cross sections are often the result. Calculating voltage drops on wires is no great feat but does involve mastering some of the uncommon values for material properties, cross sections, line lengths and their odd properties.

The following diagram will help explain: For example, if one powers a display panel located 30m away (=60m wire lengths) which requires a current of up to 4A one would expect a standard wire with a cross-section of 0.75mm² to be adequate. The diagram shows a voltage drop of 4.5V for a 1mm² line. Converted to 0.75mm² this gives a voltage drop of 6.75V which means that just 17.25V reaches the display panel instead of 24V. And this at a current of just 4 amps! These kinds of voltage drops cannot be compensated for simply by turning up the voltage on the power supply unit.

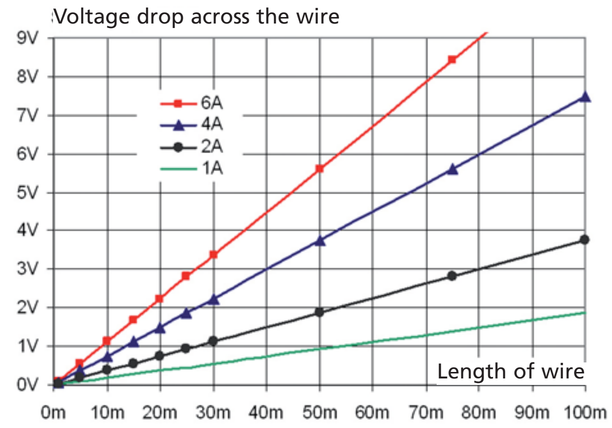

Figure 1: Voltage drop across a 1mm² wire vs. the length of the wire at a wire temperature of 30°C.

Not all DC/DC converters are suitable

It is important that the DC/DC converter has a broad specified input voltage range and that the input shutdown voltage is very low. This enables transient voltage dips to be bridged more efficiently. The converter itself must not cause an unnecessary current load on the input cable which would lead to a further larger voltage drop and which could damage the system. The DC/DC converter should instead actively limit the peak input current which occurs for instance when charging capacitors.

All these characteristics were taken into account when developing the new CD5 DC/DC converter family from PULS. As well as a broad input voltage range, the devices also have an active inrush current limiter plus a soft-start function.

Thanks to the soft-start function there is no need to worry about high input currents if choosing a 5A device for 1A load current. The input current also adjusts to the load current during the switch-on phase.

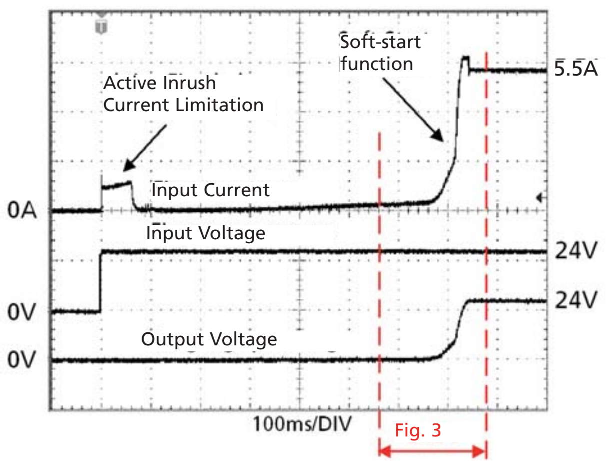

Figure 2:
CD5.241: Soft-start without noticeable current increase (24V, 5A constant current load)

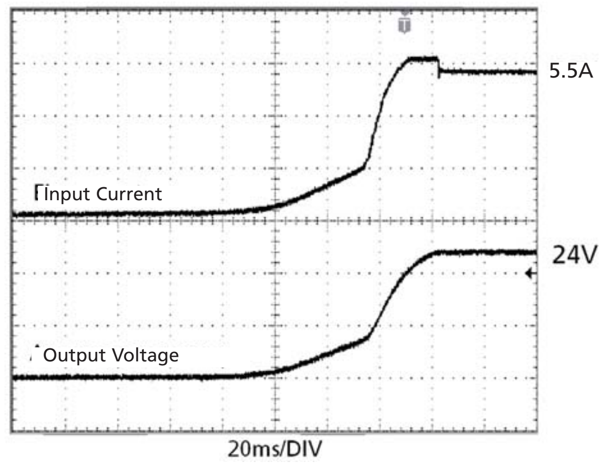

Figure 3:
CD5.241: Soft-start function. No unnecessarily high input currents during the switch-on phase.

The benefit is best explained with the following example: A controller at the end of a cable has a relatively large buffer capacitor and an average current consumption of 1.5A. Based on the low current, a correspondingly small cross-section wire is selected. To compensate the voltage loss on the cable, a 5A standard DC/DC converter is utilized to refresh the 24V. If we switch on the 24V power supply, the following takes place: The DC/DC converter will want to charge the capacitors in the control unit with its maximum possible current (typically 6.5A). In addition, the internal input capacitors in the DC/DC converter also need recharging. This naturally leads to a high current at the input of the DC/DC converter which forces the DC/DC converter into an undervoltage shut-down based on the voltage drop on the line. The result is a sequence of start-up attempts or no start up at all. It would be possible to improve this situation by selecting a 2A device, however, there is not a great deal of choices with DC/DC converter so you have to choose from what is available.

The new CD5 series has addressed these problems. After applying the input voltage, the default value for the maximum output current rises slowly to the required value. Loads connected to the output and capacitors are thus charged gently. Of coarse the start process takes a little longer but this method effectively prevents a high input current during the switch-on phase.

CD5: The New DC/DC converter family from PULS

As well as refreshing voltage losses at the end of long wire runs, the new DC/DC converter series has many more possible uses:

- Generating a stabilized control voltage in battery powered devices
- Galvanic isolation of control current circuits to avoid ground (earth) loops
- Mobile applications e.g. in ships, forklifts, …

As well as the 24V to 24V “Refresher” described here, there are other DC/DC converters which convert 24V to 12V or 48V to 24V.

All DC/DC converters have a galvanically isolated output and are specified with 120W over the temperature range of –25°C to +60°C (12V version: 96W). Higher currents can be achieved by paralleling DC/DC converters. The devices also have a 20% power reserve which can be drawn continuously below +45°C.

The flat design allows installation in standard decentralized 120mm on-machine cabinets and the width of just 32 mm saves plenty of space on the DIN-rail. The integrated soft-start, the electronic inrush current limiter, the reverse polarity protection at the input and the extensive approval package ensure a simple and problem-free installation.

The CD5.241-S1 offers a useful feature for battery powered applications and is equipped with two relay contacts. The “Input-Low contact“ can detect when a battery is running low while the “DC-OK contact“ is designed for building redundant systems. In this device the input/output terminals are also equipped with vibration-proof quick-connect spring clamp terminals. All other devices have screw terminals for the connection of wires.

Ultimately these DC/DC converters do more than just adjust voltages. They contribute to system reliability and increase endurance in the event of voltage fluctuations. Thanks to their compact design, retrofitting is almost always possible.