The majority of communications equipment is designed to operate from a DC power system with a nominal voltage of -48 V. DC-DC converters are used on each card in the equipment to reduce the voltage to a suitable level for the ICs and other components, and to maintain isolation for safety. In some applications, mainly cell sites, a nominal system voltage of +24 V is used rather than -48 V, and there is therefore a need for equipment that can operate from either power system voltage. This article examines the range of voltage needed and considers what options can be used to minimize the impact of the wide voltage range on the DC-DC converters.

Nominal 48 V input range

Although the power system voltage is referred to as -48 V, the actual voltage varies over a range from -42 to -56 V depending on the state of charge of the batteries. The DC-DC converters themselves must operate down to a significantly lower input voltage, to allow for voltage drops within the equipment. Typically the minimum is about -38 V, derived as illustrated in Figure 1.

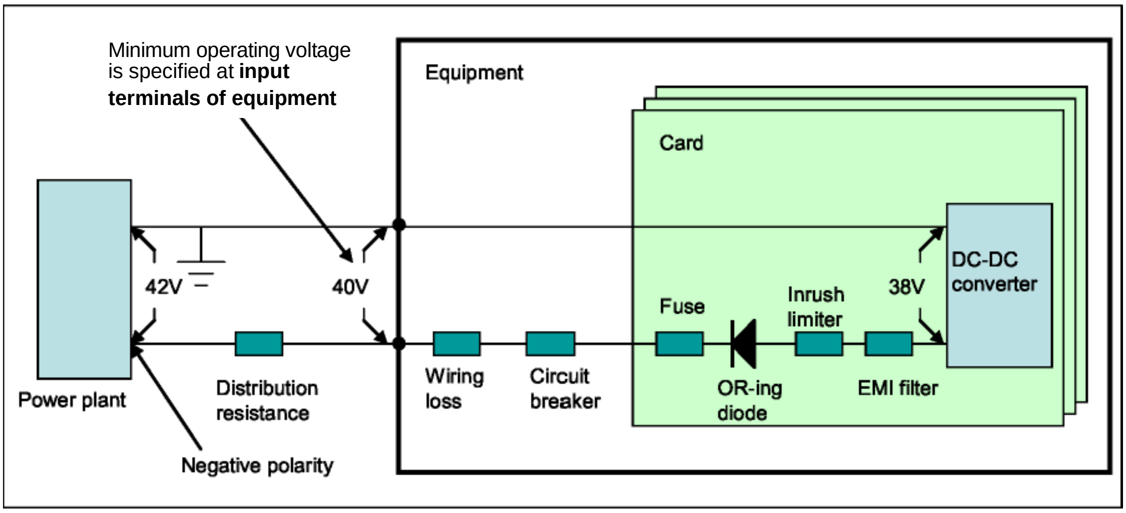

Figure 1 – Minimum input voltage at DC-DC converter

Most systems include a low input shutdown (LISD) function, to shut down the DC-DC converters if the input voltage falls below the minimum. Assuming the LISD is set to 37±1 V, the minimum voltage at the DC-DC converter is 36 V.

At the other extreme, the maximum voltage for a -48 V power system is normally specified to be -60 V continuous, with transients up to -100 V (refer to ANSI T1.315). However, some central offices use a nominal -60 V power system rather than the normal -48 V. Even though this type of power system is only used in a limited number of areas, mainly in Europe, most large equipment manufacturers prefer to make a single product that can be used in all applications. Consequently, it has become commonplace to design equipment that can operate on either -48 V or -60 V, and the maximum continuous input voltage to the DC-DC converter is increased to -72 V.

Most commonly available DC-DC converters are therefore designed for a 2:1 input voltage of 36 to 72 V, or sometimes 36 to 75 V.

Nominal 24 V operation

In some applications, particularly in cell sites, the DC power system has a nominal voltage of 24 V rather than 48 V. This allows the RF power amplifiers to be fed directly from the battery voltage with no DC-DC converter, simplifying the equipment and improving efficiency and cost. A 24 V battery has a voltage range from about 21 to 30 V, and the minimum voltage at the DC-DC converters is approximately 19 V because of the voltage drop in the distribution. If the LISD is set to 18.5±0.5 V, the minimum operating voltage for the DC-DC converters must be 18 V. Most DC-DC converters for this application are designed for an input voltage of 18 to 36 V, again a 2:1 range.

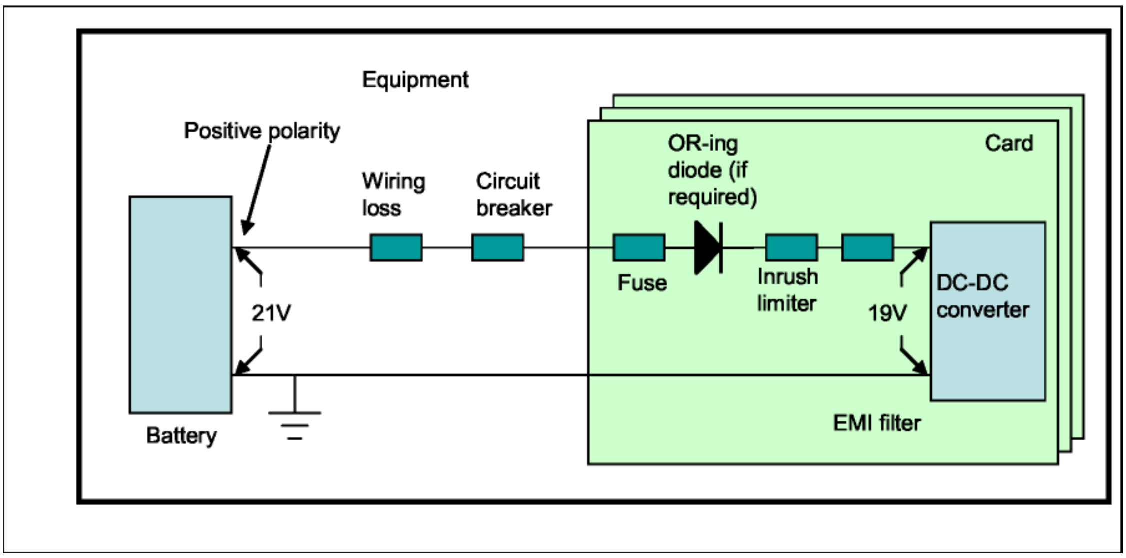

Figure 2 – Minimum input voltage in 24V system

Note that the distribution voltage drops must be approximately half those in a 48 V system, as shown in Figure 2. This may be achieved by locating the power plant within (or very close to) the equipment, and by careful design of the power distribution within the equipment to minimize losses. When the equipment and power plant are located within the same cabinet, it may also be possible to eliminate the ORing diode since redundant feeds are not needed.

Dual input range

Although many older cell sites use 24 V power systems, most newer sites now use 48 V. There is therefore a need for cell-site equipment manufacturers to offer products that can be used in either a 24 V or a 48 V application. One way to achieve this is to design the DC-DC converters to operate from the full 4:1 input voltage range of 18-72 V. Although this approach is possible, it makes the design of the DC-DC converters much more difficult, reducing the performance and increasing the cost. The operating duty-cycle must vary over the 4:1 range, leading to very high peak currents and reduced efficiency. The switching components must be able to handle both high current (at minimum input) and high voltage (at maximum input), forcing compromises in component selection. Furthermore, the same constraints apply to the other primary components on the cards: the fuse, ORing diode, inrush limiter and EMI filter must all be capable of handling twice as much current as in a 48V system but must still be rated for at least 72 V (100 V peak). The distribution wiring must also be much heavier gauge, since fuses and circuit breakers chosen for the 24 V current rating will provide much less protection against overloads and faults.

A further complication is that the polarity of the 24 V system is normally positive, whereas the polarity of 48 V and 60 V systems is normally negative. Although it is possible to design equipment with a floating primary that can be grounded in either polarity, this requires additional compromises and can make it more difficult to achieve regulatory approval.

Pre-converter

An alternative approach that minimizes the need for compromise is to design the equipment itself for 48 V input and use a pre-converter in 24V applications. This approach is illustrated in Figure 3.

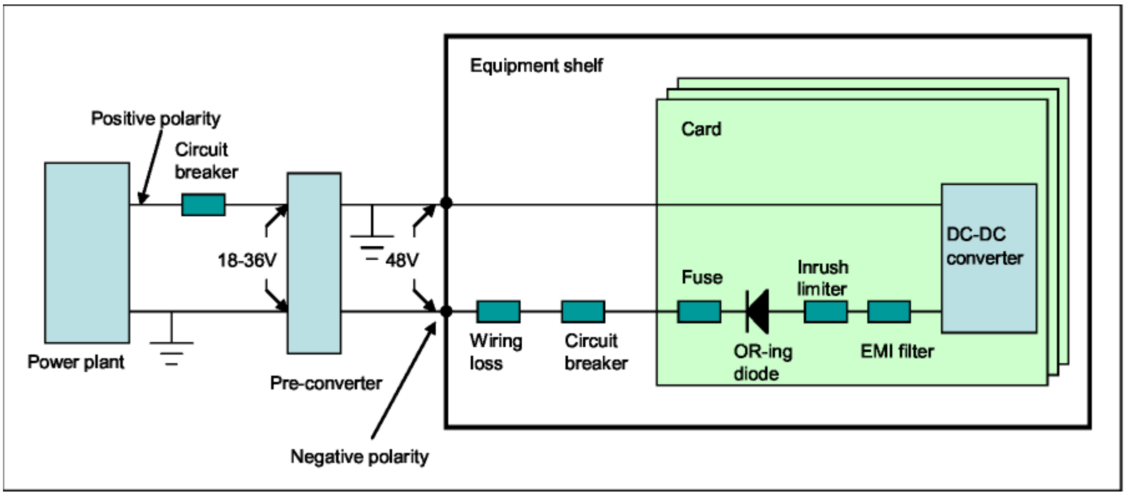

Figure 3 – 24 V power system with pre-converter

With this approach, all the DC-DC converters in the equipment shelf, as well as the primary circuits on the cards, only have to handle voltages close to the nominal 48 V because the pre-converter provides regulation. The system efficiency is slightly reduced due to the double conversion, although the pre-converter only requires a 2:1 input range and can achieve better than 90% efficiency. The loss of efficiency can be offset somewhat because the limited voltage range at the output of the pre-converter allows the efficiency of the DC-DC converters on the cards to be higher than in a normal 48 V application. Furthermore, because the pre-converter provides isolation the equipment does not need any added components to deal with the change of polarity.

With this solution, in applications where the equipment is powered from 48 V the pre-converter can be simply omitted. This means that the overall system efficiency and cost in these applications are unaffected by the dual range input capability. In contrast, the use of wide-range input DC-DC converters on each card compromises cost and performance in all applications, both 24 V and 48 V.

Comparison of options

The table below gives a comparison of options for equipment that must be capable of operation from either -48 V or +24 V:

OPTION	ADVANTAGES	DISADVANTAGES
Separate products for 24 V, 48 V	• Product can be optimized for each input voltage	• Two separate products must be designed and supported. • All cards affected
Wide range DC-DC converters on each card	• Single product covers full range with no hardware changes	• DC-DC converters difficult to design - Very few sources available - Reduced efficiency • Card input circuits must handle high current and high voltage - Inrush limit (hot swap) very difficult to design - Input capacitors very large • Reduced fault protection • Must handle dual input polarity
Pre-converter for 24 V system	• Main product used over full range • 48 V applications unaffected • No impact on card DC-DC converters • No impact on card input circuits • No requirement to handle dual input polarity	• Power efficiency lower for 24 V application • Pre-converter option card/module required for 24 V application

Application example

Traditional cell sites have a +24 V power system to suit first-generation cellular network equipment. The next generation of cellular and mobile equipment, for GSM (Global System for Mobile) communications and 3G (Third-Generation) data networks, is designed to operate from -48 V. Carriers are therefore faced with the need to either redesign the equipment or support both voltages in the same wireless base station. The pre-converter solution allows the next generation -48 V equipment to be powered from the existing +24 V battery plant as shown in Figure 4, avoiding the need to install a second power plant.

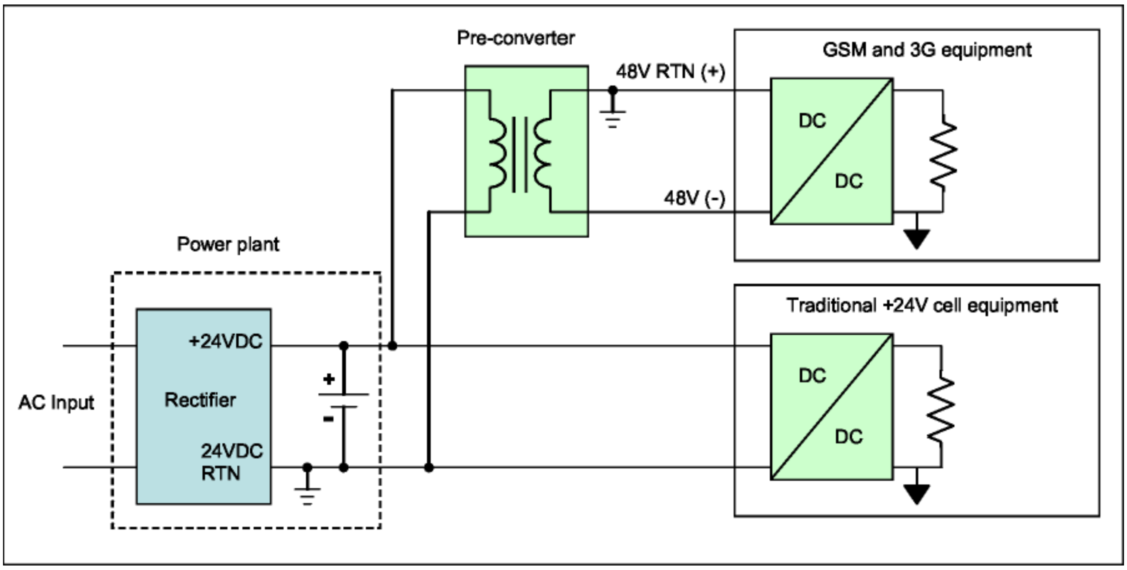

Figure 4 – Pre-converter used in cell site with 24 V battery plant

Conclusion

The use of a pre-converter offers a simple and effective solution to the problem of dual voltage DC power supplies. It allows equipment designed for 48 V to be used in applications with 24 V power, and easily accommodates the opposite polarity of the two systems. This solution avoids the need for wide input range DC-DC converters, which are not widely available, and allows improved performance of hot-swap and input filter circuits.

(1458 words)