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www.railwayinverter.com

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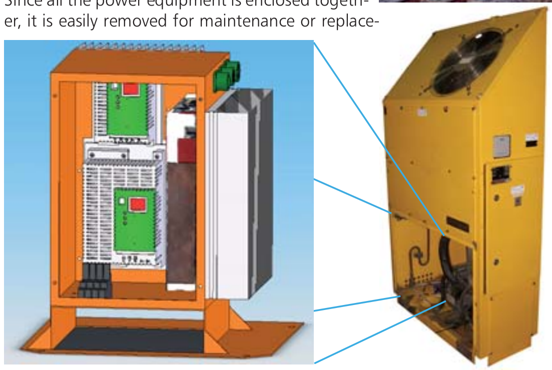
Standalone Airconditioning Power System
2800 Class Locomotive

Queensland Rail's 2800 Class locomotives haul freight in northern Queensland. The Airconditioning system is side-mounted however in this system all the power equipment is housed within one enclosure.

Since all the power equipment is enclosed together, it is easily removed for maintenance or replacement.



The 2800 Airconditioning Power System is a prime example of the advancement in power electronics for rail applications. As technology has improved, the use of higher switching frequencies and IGBT components has facilitated size and weight savings. Early versions of this power system were almost 100kg. The next model was 80kg. The current model shown here weighs only 30kg. Another factor is the reliability of this equipment. Previous models required forced ventilation. The current model is self-ventilated. This means it has no external fans and is completely enclosed so the electronic components are protected from dirt and dust. External fans require periodic cleaning and replacement. Since this model has no external fans and is completely protected from dust, it does not require such maintenance.

Standards	
EN 50155	Electronic equipment used on rolling stock
IEC 1287-1	Power converters installed on board rolling stock
EN 50121-3-1	Electromagnetic Compatibility
EN 50121-3-2	Electromagnetic Compatibility
IEC 61000-4-3	EMC standard
IEC 61373	Railway application rolling stock equipment: Shock and vibration testing
BRB/RIA-12	British Rail Standard for transients and surges
AS 3000	Wiring regulations

Quality Endorsed Company

AUSTRALASIAN RAILWAY ASSOCIATION INC MEMBER

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AIRCONDITIONER POWER SYSTEMS

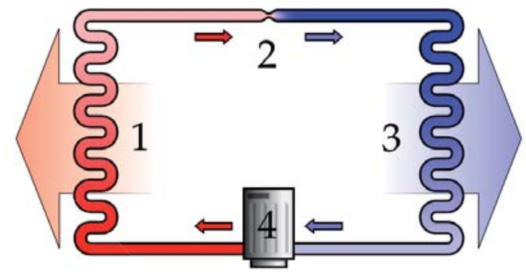
Input: 74V DC, 110V DC locomotive battery voltage
600V DC, 750V DC, 1500V DC or 25kV AC catenary
415V AC 3-phase auxiliary generator

Output: 415V AC 3-phase variable frequency
Individual fan motor / compressor motor control

Airconditioning Systems

Airconditioning systems for railways are not standardised. Each class of train has a unique airconditioning system configuration. The systems may be mounted under cars, mounted in the side of locomotives and are also quite commonly roof-mounted in passenger cars and locomotives. Though they may look different, the principles of airconditioning systems are consistant and most systems use common basic components.

A typical airconditioning system consists of a condenser section and an evaporator section. The key principle is heat transfer based on the Carnot cycle. See the figure below.



Work is done on a refrigerant substance collecting energy from the evaporator section (the cool area) and exhausting it into the condenser section (the warm area). The compressor (4) forces the refrigerant into the condenser section (1). The high pressure heats the refrigerant above the ambient temperature in the condenser so as it condenses heat energy is released to the air. The refrigerant then passes through an expansion valve (2) into the low pressure evaporator section (3). This causes another state change as the refrigerant evaporates into a cold gas and it is thus able to extract heat from the ambient air in the evaporator section (3).

To cool the air inside a train, the inside air is passed through the evaporator section. At the same time, the heat extracted from the inside air is exhausted to outside air via the condenser section.

It is quite normal that the electrical energy spent driving these loads is only a fraction of the heat energy transferred between the two sections. Hence, airconditioners are often described as being more than 100% efficient.

Airconditioner Power Systems

The electrical loads in a typical airconditioner system are the compressor that forces the refrigerant through the airconditioner and the fans that blow air through the evaporator and condenser sections. In large airconditioners, such as those used on trains, the compressor and fans are driven by three phase induction motors and thus require three phase power.

There are two ways to supply three phase power to induction motors. The first method involves one large power converter/inverter. The second involves multiple smaller inverters for each motor load.

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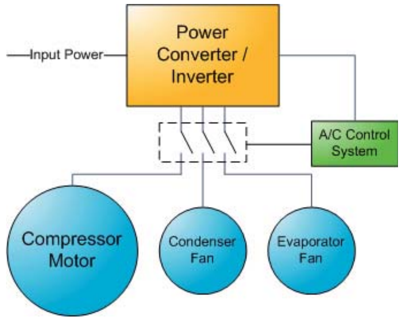
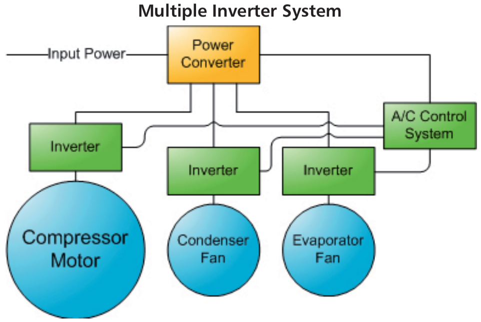
Single Inverter System



In the figure above, a large power converter/inverter creates three phase power. The A/C control system turns on or off the motor loads as necessary to maintain the desired temperature.

There are several problems with this system design. The motors are direct on-line (DOL) started. When a motor is DOL started it draws a large inrush current that exceeds the rating of the motor. This is not good for the motor. It also means that the main power converter/inverter must be far overrated which results in very large systems that only operate at full capacity for a very short period of time when motors are started. This is inefficient and unnecessary.

Multiple Inverter System



A multiple inverter system uses individual inverters to supply 3-phase power to each motor load. The A/C control system sends a start or stop signal to each inverter as necessary to maintain the desired temperature.

The advantages of this system design are:

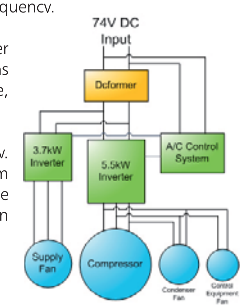
- motors are soft started
- rated power is never exceeded
- the power converter is much smaller and lighter
- motor speeds are individually controllable
- the system is more efficient
- the inverters provide individual motor protection

Because the motors are soft started, there is no inrush current. This means that the rated power is never exceeded and the front-end power converter can be smaller. The inverters can operate off 600V DC, so the power converter does not need to provide three phase AC power which has wiring and interference advantages. Variable frequency inverters facilitate more motor control so the system can maintain temperature in a more efficient manner than simply turning motors on or off. The inverters are able to be programmed with the individual specifications of each motor and can detect when a motor has been overloaded. In this way the inverters also act as a motor protection device.

81-Class Locomotive
Side-mounted Airconditioner Power System

The EMD built 81-Class locomotives are owned by Pacific National and are often seen hauling grain in NSW. The Airconditioning System is mounted on the side of the locomotive and can be removed by forklift.

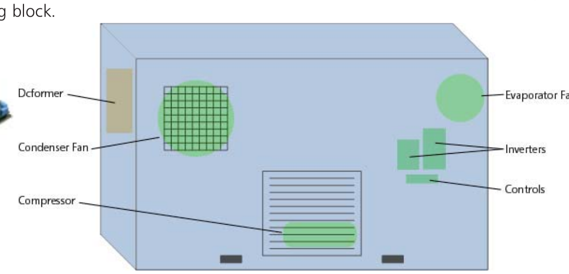
The A/C power system comprises a 'Dcformer' and two Inverters. The Dcformer converts the incoming 74V DC (nominal battery voltage) and produces a regulated 600V DC. This is then used by the inverters to generate 415V AC three phase at variable frequency.



In this system the supply fan (evaporator fan) is connected to it's own 3.7kW inverter. However the compressor and condenser fan are connected to the one inverter because each only runs when the other is running. Similarly the control equipment fan, which only uses a single phase, is connected to this inverter.

The physical arrangement of the power components within the airconditioner is shown below. The Dcformer is accessible from one end and can be replaced easily. It connects to the system via military-style plugs which are commonly used in railway applications. The Inverters are mounted in a cavity next to the supply fan and include the temperature controller and relays on the one mounting block.

Dcformer



Inverters

NR-Class Locomotive
Roof-mounted Airconditioner Power System

The GE built NR-Class locomotives are in operation throughout Australia for both freight and passenger services. Most notably, the Indian Pacific running from Sydney to Perth and the Ghan running from Adelaide to Darwin are led by these locomotives.

The A/C system is mounted in the roof above the single driver's cab. As with other systems, the 74V nominal battery voltage is converted and regulated to 600V DC. This is then used by inverters to generate 415V three phase power for the motor loads.

Naturally, the physical arrangement is quite different from the side-mounted systems, but the electrical schematic is virtually identical. The DCformer and inverters are again contained within the airconditioner unit and are identified in the exploded view below.