A series hybrid power supply system for a trailer box refrigeration system is disclosed. The trailer box refrigeration system may use either a DC or an AC motor to power the compressor. The power system alternator produces power to power refrigeration system loads.
Fig. 2

RECTIFIERS 115

INVERTER 205

ALTERNATOR 105

MOTOR 203

ENGINE 103

COMPRESSOR 109
TRANSPORT REFRIGERATION SERIES HYBRID POWER SUPPLY

BACKGROUND OF THE INVENTION

[0001] The invention relates generally to the field of transport refrigeration systems. More specifically, the invention relates to transport refrigeration systems employing a series hybrid power supply outputting direct current (DC) to power either a DC or alternating current (ac) compressor motor.

[0002] Transport refrigeration systems such as those used on truck trailers, typically employ a mechanically coupled shaft driven compressor or an electric motor driven compressor. In the mechanical scheme, an engine such as a diesel is either directly or indirectly coupled to the refrigeration compressor. The engine may also drive the refrigerant condenser fans, evaporator fans, and other components through additional mechanical drives using pulleys, V-belts and the like.

[0003] For mechanical refrigeration systems, electric power is limited. Usually, the only available power is 12 VDC that is available from the refrigeration system engine battery. This low voltage may be used to supply power for lighting within a trailer box or for a lift gate mechanism.

[0004] In the electrical scheme, the engine is coupled to an alternator which provides single or polyphase ac power for all refrigeration loads. Refrigeration loads typically include a compressor motor, condenser fan motors, evaporator fan motors, electric defrosting heaters, and other ac loads.

[0005] What is desired is a system that provides DC to power DC and ac loads.

SUMMARY OF THE INVENTION

[0006] The inventors have discovered that for electrical transport refrigeration systems, a DC distribution for DC motors provides less expensive motor speed control than ac motors, a lower cost load distribution bus since the number of conductors is reduced as compared with polyphase ac systems as well as the number of contactor poles, and the inherent simplicity in understanding DC systems.

[0007] A series hybrid power supply system using a DC distribution bus is taught for a trailer box refrigeration system. The trailer box refrigeration system may use either a DC or an ac motor to power its associated compressor. The series hybrid alternator produces power which is full wave rectified for DC refrigeration system loads.

[0008] One aspect of the invention provides a series hybrid mobile refrigeration power supply system for an electric transport refrigeration system cooling a trailer box. Systems according to this aspect of the invention comprise an engine coupled to an alternator for providing an alternating current output, a rectifier bridge coupled to the output of the alternator for converting the alternating current to direct current, a distribution bus coupled to the rectifier bridge for distributing direct current to a plurality of loads, and a compressor motor coupled to the direct current bus to supply power to the compressor motor when required by cooling demand.

[0009] Another aspect of the invention provides a system for providing electric power for an electric transport refrigeration system used to cool a trailer box. Systems according to this aspect of the invention comprise an engine coupled to an alternator for providing an alternating current output, a rectifier bridge coupled to the output of the alternator for converting the alternating current to direct current, a distribution bus coupled to the rectifier bridge for distributing direct current to a plurality of mobile refrigeration system loads, and a direct current compressor motor electrically coupled to the distribution bus using a contactor as a switching device to energize the compressor motor when required by cooling demand.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is an exemplary schematic diagram for a series hybrid AC alternator outputting dc to power a dc compressor motor for a trailer box refrigeration system.

[0012] FIG. 2 is an exemplary schematic diagram for a series hybrid AC alternator outputting dc to power an AC compressor motor for a trailer box refrigeration system.

DETAILED DESCRIPTION

[0013] Embodiments of the invention will be described with reference to the accompanying drawing figures wherein like numbers represent like elements throughout. Further, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of “including,” “comprising,” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms “mounted,” “connected,” and “coupled” are used broadly and encompass both direct and indirect mounting, connecting, and coupling. Further, “connected” and “coupled” are not restricted to physical or mechanical connections or couplings.

[0014] Shown in FIG. 1 is a first embodiment 101 of a series hybrid dc power distribution system for a mobile refrigeration unit. In a series hybrid configuration, a gasoline or diesel engine 103 turns a synchronous alternator 105 to generate power for an electric motor 107 that operates a compressor 109 for the mobile refrigeration system. The engine 103 never directly powers the compressor 109.

[0015] The alternator 105 generates a voltage at a frequency 111 that vary linearly with the angular velocity of the engine 103. The engine 103 speed 113 may be unregulated or regulated using an engine governor (not shown). In a preferred embodiment, the system is designed to operate at a plurality of engine speeds 113, the selection of which is determined by a controller to meet the required conditions of the refrigerated space.

[0016] The alternator 105 may output single phase or polyphase ac and is used to provide power to the compressor 109 drive motor 107, and may power condenser fan motors, electrically powered evaporator fan motors, serpentine heater elements, evaporator coil heaters, and a host of electrical and electronic control devices such as a suction modulation valve solenoid, a display keyboard module, and the like (not shown).

[0017] The structure of the integrally mounted engine driven alternator 105 unit is small to allow it to be easily coupled directly to the drive shaft of an engine 103. As a result, a single rotatable drive shaft which is common to both
the alternator 105 and engine 103 allows the alternator 105 and engine 103 to be configured to operate as a single unitary mounted unit. The engine 103 may be coaxially coupled to the alternator 105, or may be coupled using an intermediate power transmission device. Various types of mechanical drive mechanisms including gear trains and other known mechanical drive devices may be used.

Coupled to the output of the alternator 105 is a bridge rectifier 115 for single phase alternator 103 outputs and/or a polyphase diode bridge 115 for polyphase alternator 103 outputs. A bridge rectifier (diode bridge) is an arrangement of diodes connected in a bridge circuit that provides the same polarity of output DC voltage for any polarity of input AC voltage. The bridge rectifier provides full wave rectification from a single phase or polyphase AC input.

The rectified DC is output from the rectifier 115 onto a distribution bus 117 for distributing power to all DC fed loads.

What is claimed is:

1. A series hybrid mobile refrigeration power supply system comprising:
   - an engine coupled to an alternator, the alternator configured to provide an alternating current output;
   - a rectifier bridge coupled to the output of the alternator, the rectifier bridge configured to convert alternating current to direct current;
   - a distribution bus coupled to the rectifier bridge to distribute direct current to a plurality of mobile refrigeration system loads; and
   - a direct current compressor motor electrically coupled to the distribution bus using a contactor as a switching device, the contactor energizes the compressor motor when required by refrigeration cooling demand.

2. The system according to claim 1 wherein the engine is a gasoline engine.
3. The system according to claim 1 wherein the engine is a diesel engine.
4. The system according to claim 1 wherein the alternator outputs single phase AC.
5. The system according to claim 1 wherein the alternator outputs polyphase AC.
6. An electric transport refrigeration system used to cool a trailer box comprising:
   - an engine coupled to an alternator, the alternator configured to provide an alternating current output;
   - a rectifier bridge configured to convert the alternating current to direct current;
   - a distribution bus coupled to the rectifier bridge to distribute direct current to a plurality of electric transport refrigeration system loads;
   - an inverter coupled to the direct current bus, the inverter configured to invert the direct current to alternating current; and
   - an alternating current compressor motor electrically coupled to the inverter using a contactor as a switching device, the contactor energizes the compressor motor when required by refrigeration cooling demand.
7. The system according to claim 6 wherein the engine is a gasoline engine.
8. The system according to claim 6 wherein the engine is a diesel engine.
9. The system according to claim 6 wherein the alternator outputs single phase AC.
10. The system according to claim 6 wherein the alternator outputs polyphase AC.

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