Title: METHODS AND SYSTEMS FOR POWER MANAGEMENT OF A TRANSPORT REFRIGERATION SYSTEM

Abstract: Systems and methods for power management of a transport refrigeration system (TRS) are provided. In particular, methods and systems are provided for power management of a TRS when a generator set (genset) of the TRS is not running. The TRS includes a telematics Unit (TU) configured to control power management of the TRS when the genset is not running. The TU is also configured to obtain telemetry data of the TRS when the TRU is off and provide the telemetry data to a host service when the genset is not running.
METHODS AND SYSTEMS FOR POWER MANAGEMENT OF A TRANSPORT REFRIGERATION SYSTEM

The embodiments disclosed herein relate generally to a transport refrigeration system (TRS). More particularly, the embodiments relate to methods and systems for power management of a TRS.

BACKGROUND

Existing transport refrigeration systems are used to cool containers, trailers, and other similar transport units (typically referred to as a "reefer"). Modern reefers may be efficiently stacked for shipment by ship, rail or truck. When cargo in the container includes perishable products (e.g., food product, flowers, etc.), the temperature of the reefer must be controlled to limit loss of the cargo during shipment.

SUMMARY

The embodiments described herein are directed to a TRS. In particular, the embodiments described herein are directed to methods and systems for power management of a TRS.

The embodiments described herein provide power management of a TRS when a generator set (genset) of the TRS is not running. That is, the embodiments provided herein prevent a Transport Refrigeration Unit (TRU) of the TRS from not starting due to a battery of the TRU being depleted when the genset is not running. The embodiments provided herein also allow a Telematics Unit (TU) of the TRS to obtain telemetry data of the TRS when the TRU is off and provide the telemetry data to a host service when the genset is not running.

In some embodiments, a method and system for providing power management of a TRS can be started via ignition line sensing and/or battery voltage sensing of a TRU battery.
In some embodiments, the TU has a backup battery that allows the TRU to still obtain and send telemetry data to a host service when a battery level of a TRU battery is below a minimum threshold for the TRU battery.

In some embodiments, when the TRU is turned off and a battery level of the TRU battery is below a minimum threshold for the TRU battery, the TRS is configured to operate in a conservative mode and the TU is configured to notify a host service of the TRU battery level via, for example, an e-mail, a text message, etc.

In some embodiments, a power management method and system is provided that uses hysteresis when switching between different modes of the power management method and system to avoid a ping pong effect.

In some embodiments, a configurable wakeup time interval for the TU is provided when the TU is off to allow the TU to obtain and send telemetry data to a host service.

Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings in which like reference numbers represent corresponding parts throughout.

FIG. 1 illustrates a side perspective view of a temperature controlled container with a transport refrigeration system, according to one embodiment.

FIG. 2 illustrates a block diagram of a portion of a TRS, according to one embodiment.

FIG. 3 illustrates a state chart of a method and system for power management of the TRS when a genset of the TRS is not running, according to one embodiment.

FIG. 4 illustrates a current vs. time graph of a power management method and system of a TRS, according to one embodiment.
DETAILED DESCRIPTION

The embodiments described herein are directed to a transport refrigeration system (TRS). More particularly, the embodiments relate to methods and systems for power management of a TRS.

References are made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration of the embodiments in which the methods and systems described herein may be practiced. The term "reefer" generally refers to, for example, a temperature controlled trailer, container, or other type of transport unit, etc. The term "transport refrigeration system" or "TRS" refers to a refrigeration system for controlling the refrigeration of an in internal space of the reefer. The term "TRS controller" refers to an electronic device that is configured to manage, command, direct and regulate the behavior of one or more TRS refrigeration components (e.g., an evaporator, a blower, a heat exchanger, etc.), a genset, etc. The term "telemetry data" refers to data that can include, for example, transport unit temperature data, ambient temperature data, humidity level data within the transport unit, humidity level data outside of the transport unit, TRS set-point data, TRS alarm notification data, geographical location data of the transport unit, fuel level data of the genset, engine speed data of an engine of the genset, operating time data of the genset, etc. The term "host service" refers to, for example, a driver of the transport unit and/or a service center. The host service can be communicated to via a first party telematics communication system that is part of a telematics unit of the TRS or a third party telematics communication system that is separate from the telematics unit of the TRS.

It will be appreciated that the embodiments described herein may be used in any suitable temperature controlled apparatus such as a ship board container, an air cargo cabin, an over the road truck cabin, etc. The transport refrigeration system may be a vapor-compressor type refrigeration system, or any other suitable refrigeration systems that can use refrigerant, cold plate technology, etc.

FIG. 1 illustrates a side view of a temperature controlled container unit 100 with a TRS 110 that includes a TRU 115 connected to a Genset 120. The container unit 100 can be disposed on a ship, on a train or a truck. The TRU 115 is installed on a side wall of
the container unit 100. The TRS 110 is configured to transfer heat between an internal space 130 and the outside environment. In some embodiments, the TRS 110 is a multi-zone system in which different zones or areas of the internal space 130 are controlled to meet different refrigeration requirements based on the cargo stored in the particular zone.

As shown in FIG. 1, the TRU 115 is positioned adjacent to a front side of the transport unit 100 and is enclosed in a housing 135. The TRU 115 is in communication with the space 130 and controls the temperature in the space 130. The TRU 115 includes a TRS Controller (not shown) and a closed refrigerant circuit (not shown). The TRS Controller controls the refrigeration circuit to obtain various operating conditions (e.g., temperature, humidity, etc.) of the space 130 and is powered by the generator set 120. The TRS Controller can also be powered by a TRU battery and/or a backup battery. The closed refrigerant circuit regulates various operating conditions (e.g., temperature, humidity, etc.) of the space 130 based on instructions received from the TRS controller. The refrigeration circuit can include, for example, an Electronic Throttle Valve (ETV), a compressor coupled to a condenser and an evaporator that cools the space 130 and the perishable cargo.

The genset 120 generally includes an engine (not shown), a fuel container (not shown) and a generator (not shown). The engine may be an internal combustion engine (e.g., diesel engine, etc.) that may generally have a cooling system (e.g., water or liquid coolant system), an oil lubrication system, an air filtration system (not shown), etc. The air filtration system filters air directed into a combustion chamber (not shown) of the engine. The fuel container is in fluid communication with the engine to deliver a supply of fuel to the engine. In some embodiments the engine is not specifically configured for the TRS 110, but can be a non-industrial engine such as, for example, an automotive engine.

FIG. 2 illustrates a block diagram of a portion of one embodiment of a TRS 200. The TRS 200 includes a TRU 210, a TU 220 and a genset 230. The TRS 200 also includes a TRU battery 240 and optionally a TU backup battery 250. The TRU 210 includes a TRS controller 260.
The TRU 210, using the TRS controller 260, is configured to monitor and regulate various operating conditions (e.g., temperature, humidity, etc.) of an interior space of a transport unit (not shown) connected to the TRU 210. The genset 230 is configured to provide power to the TRU 210 in order to maintain a desired temperature in an interior space of a transport unit. That is, the genset 230 is configured to provide power to the TRU 210 in order to, for example, allow the TRU 210 to regulate various operating conditions (e.g., temperature, humidity, etc.) of the interior space of the transport unit.

The TU 220 is connected to the TRS controller 260 and various sensors (not shown) in the TRS 200 such as, for example, one or more door monitoring sensors, one or more transport unit temperature monitoring sensors, one or more ambient temperature monitoring sensors, one or more transport unit humidity level monitoring sensors, ambient humidity level monitoring sensors, one or more alarm notification sensors, a geographical location sensor, one or more fuel monitoring sensors, one or more engine speed data sensors of the genset, an operating timed data of the genset sensor, etc.

The TU 220 is configured to monitor the status of different aspects of the TRS 200 including, for example, a status of different doors on the transport unit, a fuel level of the genset 230, a temperature within the transport unit, an ambient temperature surrounding the transport unit; a humidity level within the transport unit; an ambient humidity surrounding the transport unit; a geographical location of the transport unit; an engine speed data from the genset 230; an alarm notification data etc, to obtain telemetry data of the TRS 200. The TU 220 is also configured to send the telemetry data to a host service such as, for example, a driver of the transport unit and/or a service center. In some embodiments, the TU 220 can send the telemetry data to the host service via an e-mail and/or a text message (e.g., a Short Message Service (SMS) text). In other embodiments, the TU 220 sends the telemetry data to a remote server (not shown) that provides the telemetry data to the host service via a website.

The TU 220 is also connected to and can be powered by the genset 230, the TRU battery 240 and, when provided, the TU backup battery 250. Both the TRU battery 240 and the TU backup battery 250 are connected to the genset 230. Accordingly, when the
genset 230 is running, the TRU battery 240 and the TU backup battery 250 can be charged. As described in more detail below, when the genset 230 is not running, the TRU battery 240 and TU backup battery 250 are configured to provide power as required to the TRU 210 and the TU 220.

FIG. 3 illustrates a state chart 300 of a method and system for power management of the TRS when a genset of the TRS is not running, according to one embodiment. Power management of the TRS 200 can be activated when the TRU 210 is off by way of ignition line sensing of the genset 230 and/or via instruction commands to verify power status of the TRU 210. Also, power management of the TRS 200 can be activated by voltage level sensing of the TRU battery 240 and/or the TU backup battery 250.

The state chart 300 includes different power management modes for the TRS 200 that are controlled by the TU 220. The state chart 300 includes a Full-On Mode 310, a Countdown Mode 320, a Full-Null Mode 330, a Conservative Mode 340, a TU1 Mode 350 and a TU2 Mode 360. The power management embodiments described below can be enabled and/or disabled via the TU 220. When disabled, the TU 220 will switch the TRS 200 directly into the Full-Null Mode 330 when the genset 230 is not running and will keep the TRS 200 in the Full-Null Mode 330 until power management is enabled or the genset 230 is turned on. In some embodiments, power management of the TRS 200 is enabled by default. Each of the modes in the state chart 300 are configured to allow the genset 230 to be started using the TRU battery 240.

In the Full-On Mode 310, both the TRU 210 and the TU 220 receive power and all components of the TRU 210 and the TU 220 can operate. The TRS 200 operates in the Full-On Mode 310 when the TRU battery 240, a control area network of the TRS 200 and an ignition feedback line of the TRS 200 are all active and the TRU battery 240 is at or above a minimum threshold battery level to provide power to the TRU 210 and the TU 220 while the genset 23 is not running and allow the TRU battery 240 to start an engine of the genset 230. In some embodiments, the minimum threshold battery level for the TRU battery 240 can be, for example, -12.2 volts. The ignition feedback line can indicate when the TRU 210 is ON or OFF.
The TU 220 can switch the TRS 200 from the Full-On Mode 310 to the Countdown Mode 320 when the ignition feedback line of the TRS 200 and the control area network of the TRS 200 are inactive while the TRU battery 240 remains active and is at or above the minimum threshold battery level for the TRU battery 240. The TU 220 can switch the TRS 200 from the Full-On Mode 310 to the Full-Null Mode 330 when the TRU battery 240 is not active (e.g., disconnected) or is below the minimum threshold battery level for the TRU battery 240, the TRS 200 does not include a TU backup battery 250 or the TU backup battery 250 is below a minimum threshold battery level for the TU backup battery 250, or both a countdown mode counter and a conservative mode counter reach zero. In some embodiments, the minimum threshold battery level for the TU backup battery 250 can be, for example, -5.28 volts.

The countdown mode counter is a configurable counter that counts down from a configurable countdown mode threshold value \( C_1 \) each time the countdown mode has been activated. Similarly, the conservative mode counter is a configurable counter that counts down from a configurable conservative mode threshold value \( C_2 \) each time the conservative mode has been activated. In some embodiments, the configurable countdown mode threshold value \( C_1 \) is set to an integer value in a range between, for example, ~24 to ~96. Also, in some embodiments, the configurable conservative mode threshold value \( C_2 \) is set to an integer value in a range between, for example, ~24 to ~96.

In the Countdown Mode 320, the TU 220 is turned off and the TRU 210 has no power. The Countdown Mode 320 is an energy conservation mode that allows the TU 220 to periodically switch to the TUi Mode 350 so that telemetry data can be sent to the host service. The TRS 200 operates in the Countdown Mode 320 when the ignition feedback line and the control area network are both inactive while the TRU battery 240 is active and the battery level of the TRU battery 240 is at or above a minimum threshold battery level to provide power to the TU 220. Even though the control area network is inactive, the TU 220 can be configured to send an echo command to verify the absence of communication between the TU 220 and the TRS Controller 260. Also, the TU can be configured to notify the host service that the TRS 200 is in the Countdown Mode 320 via, for example, an e-mail, a text message, etc.
The TU 220 can switch the TRS 200 from the Countdown Mode 320 to the TUi Mode 350 when a power up timer expires, or a status update request is received from the host service via a first party telematics unit service or a third party telematics unit service. In some embodiments, the power up timer is configurable and can be set to, for example, about one hour. The TU 220 can switch the TRS 200 from the Countdown Mode 320 back to the Full-On Mode 310 when the ignition feedback line of the TRS 200 is active, and the TRU battery 240 is active and is at or above the minimum threshold battery level for the TRU battery 240. The TU 220 can switch the TRS 200 from the Countdown Mode 320 to the Full-Null Mode 330 when the TRU battery 240 is not active (e.g., disconnected) or is below the minimum threshold battery level for the TRU battery 240, and the TRS 200 does not include a TU backup battery 250 or the TU backup battery 250 is below a minimum threshold battery level for the TU backup battery 250. The TU 220 can switch the TRS 200 from the Countdown Mode 320 to the Conservative Mode 340 when: 1) the ignition feedback line is inactive (thereby indicating that the TRU 210 is OFF), the TRU battery 240 is not active (e.g., disconnected) or is below the minimum threshold battery level for the TRU battery 240 for a set time period (e.g. ~five minutes), and the control area network is inactive; or 2) the countdown mode counter set to a configurable countdown threshold value $c_1$ reaches zero. By requiring that the TRU battery 240 is below the minimum threshold battery level for the TRU battery 240 for the set time period hysteresis is provided and a ping pong effect of switching between different power management modes is avoided.

In the TUi Mode 350, the TU 220 powers up to an active state from the Countdown Mode 320 so as to allow the TU 220 to send telemetry data to the host service. In particular, in the TUi Mode 350, all components of the TU 220 can be used and the TU 220 can communicate with the TRS Controller 260 via a control area network CAN, can communicate with sensors (not shown) of the TRS 200 to receive telemetry data, such as, for example, geographic location data, and can report telemetry data to the host service.

The TU 220 can switch the TRS 200 from the TUi Mode 350 back to the Countdown Mode 320 when a power down timer expires. In some embodiments, the power down timer can be set to, for example, about two minutes. The TU 220 can switch
the TRS 200 from the TUi Mode 350 to the Full-On Mode 310 when the ignition feedback line of the TRS 200 is active, and the TRU battery 240 is active and is at or above the minimum threshold battery level for the TRU battery 240.

In the Full-Null Mode 330, the TRS 200 performs a system wide shutdown of the TRU 210 and the TU 220. The genset 230 can still be started using the TRU battery 240 during the Full-Null Mode 330. The TU 220 can switch the TRS 200 from the Full-Null Mode 330 to the Full-On Mode 310 when the ignition feedback line of the TRS 200 is active, and the TRU battery 240 is active and is at or above the minimum threshold battery level for the TRU battery 240. The genset 230 can still be started using the TRU battery 240 during the Full-Null Mode 330.

In the Conservative Mode 340, the TU 220 is turned off and the TRU 210 has no power. The Conservative Mode 340 is an energy conservation mode that allows the TU 220 to periodically switch to the TU₂ Mode 360 so that telemetry data can be sent to the host service. The TRS 200 operates in the Conservative Mode 340 when the ignition feedback line and the control area network are both inactive, the TRU battery 240 is inactive or the battery level of the TRU battery 240 is below the minimum threshold battery level to provide power to the TU 220, and the TU backup battery 250 is provided and is at or above a minimum threshold battery level for the TU backup battery 250.

The TU 220 can switch the TRS 200 from the Conservative Mode 340 to the TU₂ Mode 360 when a power up timer expires, or a status update request is received from the host service via a first party telematics unit service or a third party telematics unit service. In some embodiments, the power up timer is configurable and can be set to, for example, about one hour. The TU 220 can switch the TRS 200 from the Conservative Mode 340 back to the Full-On Mode 310 when the ignition feedback line of the TRS 200 is active, and the TRU battery 240 is active and is at or above the minimum threshold battery level for the TRU battery 240. The TU 220 can switch the TRS 200 from the Conservative Mode 340 to the Full-Null Mode 330 when: 1) the TU backup battery 250 is not active (e.g., disconnected) or is below the minimum threshold battery level for the TU backup battery 250 for a set time period (e.g. ~ five minutes), the ignition feedback line of the TRS 200 is inactive and the TRU battery 240 is inactive (e.g. disconnected) or below the
minimum threshold battery level for the TRU battery 240; or the conservative mode
countdown reaches zero. By requiring that the TU backup battery 250 is below the
minimum threshold battery level for the TU backup battery 250 for the set time period
hysteresis is provided and a ping pong effect of switching between different power
management modes can be avoided.

In the TU₂ Mode 360, the TU 220 powers up to an active state from the
Conservative Mode 320 using the TU backup battery 250 so as to allow the TU 220 to
send limited telemetry data to the host service. In some embodiments, in the TU₂ Mode
360, the TU 220 is configured to only send only geographic location data to the host
service.

The TU 220 can switch the TRS 200 from the TU₂ Mode 360 back to the
Countdown Mode 320 when a power down timer expires. In some embodiments, the
power down timer can be set to, for example, about two minutes. The TU 220 can switch
the TRS 200 from the TU₂ Mode 360 to the Full-On Mode 310 when the ignition
feedback line of the TRS 200 is active, and the TRU battery 240 is active and is at or
above the minimum threshold battery level for the TRU battery 240.

FIG. 4 illustrates a current vs. time graph of the power management method and
system of the TRS 200 shown in FIG. 3, according to one embodiment. From time \( t_1 \) to
time \( t_i \) the TRS 200 is in the Full-On Mode 310 and a current \( a_1 \) is provided by the TRU
battery 240 to the TRU 210 and the TU 220.

At time \( t_1 \) the TRU 220 switches the TRS 200 to the Countdown Mode 320. As
discussed above, the TU 220 can switch the TRS 200 from the Full-On Mode 310 to the
Countdown Mode 320 when the ignition feedback line of the TRS 200 and the control
area network of the TRS 200 are inactive while the TRU battery 240 remains active and
is at or above the minimum threshold battery level for the TRU battery 240.

From time \( t_1 \) to time \( t_2 \), time \( t_3 \) to time \( t_4 \), and time \( t_5 \) to time \( t_6 \), the TRS 200 is in
the Countdown Mode 320 and has a current \( a_2 \) provided by the TRU battery 240. As
shown in Fig. 4, the TU 220 switches the TRS 200 from the Countdown Mode 320 to the
TU\(_i\) Mode 350 when the power up timer expires at times \( t_2 \) and \( t_4 \). Thus, from time \( t_2 \) to
time \( t_3 \) and time \( t_4 \) to time \( t_5 \), the TRS 200 is in the TU\(_i\) Mode 350, and the TRU battery
240 provides the current ai to operate the TRU 210 and the TU 220. Accordingly, the
TU 220 can still obtain and provide telemetry data to a host service when the genset 230
is not running. The TU 220 switches the TRS 200 from the TUi Mode 350 back to the
Countdown Mode 320 when the power down timer expires at times t3 and t5. In some
embodiments, the power up timer is configurable and can be set to, for example, about
one hour. In some embodiments, the power down timer is configurable and can be set to,
for example, about two minutes.

At time t6 the TRU 220 switches the TRS 200 to the Conservative Mode 340. As
discussed above, the TU 220 can switch the TRS 200 from the Countdown Mode 320 to
the Conservative Mode 340 when: 1) the ignition feedback line is inactive, the TRU
battery 240 is not active (e.g., disconnected) or is below the minimum threshold battery
level for the TRU battery 240 for a set time period (e.g. ~ five minutes), and the control
area network is inactive; or 2) the countdown mode counter reaches zero.

From time t6 to time t7, and time t8 to time tp, the TRS 200 is in the Conservative
Mode 340 and has a current a3 provided by the TRU battery 240. In the Conservative
Mode 340, the TRU 210 and the TU 220 are configured to draw no more than the current
a3 from the TU backup battery 240. In some embodiments, the current a3 is ~24 mA. As
shown in Fig. 4, the TU 220 switches the TRS 200 from the Conservative Mode 340 to
the TU2 Mode 360 when the power up timer expires at time t7. Thus, from time t7 to time
t8, the TRS 200 is in the TU2 Mode 360, and the TU backup battery 250 provides the
current a4 to operate the TRU 210 and the TU 220. Accordingly, the TU 220 can still
obtain and provide telemetry data to a host service when the genset 230 is not running
and the TRU battery 240 is depleted. The TU 220 switches the TRS 200 from the TU2
Mode 360 back to the Conservative Mode 340 when the power down timer expires at
time t8. In some embodiments, the power up timer is configurable and can be set to, for
example, about one hour. In some embodiments, the power down timer is configurable
and can be set to, for example, about two minutes.

At time tp the TRU 220 switches the TRS 200 to the Full-Null Mode 330. As
discussed above, the TU 220 can switch the TRS 200 from the Conservative Mode 340 to
the Full-Null Mode 330 when: 1) the TU backup battery 250 is not active (e.g.,
disconnected) or is below the minimum threshold battery level for the TU backup battery 250 for a set time period (e.g. ~ five minutes), the ignition feedback line of the TRS 200 is inactive and the TRU battery 240 is inactive (e.g. disconnected) or below the minimum threshold battery level for the TRU battery 240; or the conservative mode counter reaches zero. From time $t_9$ forward, the TRU 210 and the TU 220 are powered off and a current $a_5$ is provided to allow the TU 220 to control the TRS 200 in case an instruction is received to start the genset 230, or an instruction is received to switch the TRS 200 from the Full-Null Node 330 to another power management mode.

Aspects Section:

It is noted that any of aspects 1-8 below can be combined with any of aspects 9-15.

1. A method for power management of a transport refrigeration system comprising:
   operating the transport refrigeration system in a first energy conservation mode,
   whereby a telematics unit of the transport refrigeration system and a generator set of the transport refrigeration system are powered off and a transport refrigeration unit battery of the transport refrigeration system provides a first current, when a battery level of the transport refrigeration unit battery is above a minimum threshold battery level, the first energy conservation mode including:
   deactivating an ignition feedback line of the transport refrigeration system,
   deactivating a control area network of the transport refrigeration system,
   and
   activating the transport refrigeration unit battery;
   operating the transport refrigeration system in a first telemetry unit status update mode, whereby the telematics unit is powered on, when at least one of a first power up timer expires and a status update request is received from a host service, the first telemetry unit status update mode including:
   providing power from the transport refrigeration unit battery to the telematics unit,
   sending telemetry data to the host service.
2. The method of aspect 1, the first telemetry unit status update mode also including:
activating the control area network;
receiving the telemetry data from a transport refrigeration system controller of the
transport refrigeration system.

3. The method of aspects 1-2, wherein the telemetry data includes one or more of a
status of a door of a transport unit of the transport refrigeration system, a fuel level of the
generator set, a temperature within the transport unit, an ambient temperature
surrounding the transport unit, a humidity level within the transport unit, an ambient
humidity surrounding the transport unit, a geographical location of the transport unit, and
an engine speed data of the engine of the generator set.

4. The method of aspects 1-3, further comprising:
operating the transport refrigeration system in a second energy conservation
mode, whereby a telematics unit of the transport refrigeration system and a generator set
of the transport refrigeration system are powered off and a telematics unit backup battery
of the transport refrigeration system provides a second current greater than the first
current, when a battery level of the transport refrigeration unit battery is below the
minimum threshold battery level, the second energy conservation mode including:
deactivating the ignition feedback line,
deactivating the control area network, and
activating the telematics unit backup battery;
operating the transport refrigeration system in a second telemetry unit status
update mode, whereby the telematics unit is powered on, when at least one of a second
power up timer expires and the status update request is received from the host service, the
second telemetry unit status update mode including:
providing power from the telematics unit backup battery to the telematics
unit,
sending limited telemetry data to the host service.
5. The method of aspect 4, the second telemetry unit status update mode also including:
   activating the control area network;
   receiving the limited telemetry data from the transport refrigeration system controller.

6. The method of aspect 4, wherein the limited telemetry data includes a geographical location of the transport unit.

7. The method of aspects 1-6, further comprising:
   operating the transport refrigeration system in a full null mode for powering off the telematics unit, the generator set, and the transport refrigeration unit when:
   at least one of a telematics unit backup battery of the transport refrigeration system is not active and a battery level of the telematics unit backup battery is below a second minimum threshold battery level,
   at least one of the transport refrigeration unit battery is not active and the battery level of the transport refrigeration unit battery is below the minimum threshold battery level.

8. The method of aspects 1-6, further comprising:
   operating the transport refrigeration system in a full on mode for starting the generator set when the battery level of the transport refrigeration unit battery is above the minimum threshold battery level, the full on mode including:
   activating the transport refrigeration unit battery,
   activating the control area network,
   activating the ignition feedback line.

9. A transport refrigeration system comprising:
   a transport refrigeration unit including a transport refrigeration system controller and a refrigeration circuit, wherein the transport refrigeration system controller is
configured to regulate an operating condition of an interior space of a transport unit of the
transport refrigeration system;

- a telematics unit connected to the transport refrigeration system controller, the
  telematics unit configured to generate telemetry data based on an operating condition
  status of the transport refrigeration system;
- a generator set connected to the transport refrigeration unit and the telematics
  unit, the generator set includes an engine, and the generator set is configured to provide
  power to the transport refrigeration unit and the telematics unit; and
- a transport refrigeration unit battery connected to the transport refrigeration unit,
  the telematics unit and the generator set, wherein the transport refrigeration unit battery is
  configured to provide power to the transport refrigeration unit and the telematics unit
  when the generator set is not running;

  wherein the telematics unit is further configured to control a power management
  mode of the transport refrigeration system based on a battery level of the transport
  refrigeration unit battery when the generator set is not running.

10. The transport refrigeration system of aspect 9, wherein the telematics unit is
configured to generate the telemetry data based on the operation condition status of at
least one of a door of a transport unit of the transport refrigeration system, a fuel level of
the generator set, a temperature within the transport unit, an ambient temperature
surrounding the transport unit, a humidity level within the transport unit, an ambient
humidity surrounding the transport unit, a geographical location of the transport unit, and
an engine speed data of the engine of the generator set.

11. The transport refrigeration system of aspects 9-10, wherein the telematics unit is
configured to send the telemetry data to a host service via at least one of an e-mail and a
short message service text.

12. The transport refrigeration system of aspects 9-11, wherein the telematics unit is
configured to send the telemetry data to a remote server.
13. The transport refrigeration system of claim 9, further comprising a telematics unit backup battery connected to the telematics unit and configured to provide power to the telematics unit when the generator set is not running.

14. The transport refrigeration system of aspect 13, wherein the generator set is configured to charge the telematics unit backup battery when the generator set is running.

15. The transport refrigeration system of aspects 9-14, wherein the generator set is configured to charge the transport refrigeration unit battery when the generator set is running.

With regard to the foregoing description, it is to be understood that changes may be made in detail, especially in matters of the construction materials employed and the shape, size and arrangement of the parts without departing from the scope of the present invention. It is intended that the specification and depicted embodiment to be considered exemplary only, with a true scope and spirit of the invention being indicated by the broad meaning of the claims.
CLAIMS:

1. A method for power management of a transport refrigeration system comprising:
   operating the transport refrigeration system in a first energy conservation mode,
   whereby a telematics unit of the transport refrigeration system and a generator set of the
   transport refrigeration system are powered off and a transport refrigeration unit battery of
   the transport refrigeration system provides a first current, when a battery level of the
   transport refrigeration unit battery is above a minimum threshold battery level, the first
   energy conservation mode including:
   deactivating an ignition feedback line of the transport refrigeration system,
   deactivating a control area network of the transport refrigeration system,
   and
   activating the transport refrigeration unit battery;
   operating the transport refrigeration system in a first telemetry unit status update
   mode, whereby the telematics unit is powered on, when at least one of a first power up
   timer expires and a status update request is received from a host service, the first
   telemetry unit status update mode including:
   providing power from the transport refrigeration unit battery to the
   telematics unit,
   sending telemetry data to the host service.

2. The method of claim 1, the first telemetry unit status update mode also including:
   activating the control area network;
   receiving the telemetry data from a transport refrigeration system controller of the
   transport refrigeration system.

3. The method of claim 1, wherein the telemetry data includes one or more of a
   status of a door of a transport unit of the transport refrigeration system, a fuel level of the
   generator set, a temperature within the transport unit, an ambient temperature
   surrounding the transport unit, a humidity level within the transport unit, an ambient
humidity surrounding the transport unit, a geographical location of the transport unit, and
an engine speed data of the engine of the generator set.

4. The method of claim 1, further comprising:
   operating the transport refrigeration system in a second energy conservation
   mode, whereby a telematics unit of the transport refrigeration system and a generator set
   of the transport refrigeration system are powered off and a telematics unit backup battery
   of the transport refrigeration system provides a second current greater than the first
   current, when a battery level of the transport refrigeration unit battery is below the
   minimum threshold battery level, the second energy conservation mode including:
   deactivating the ignition feedback line,
   deactivating the control area network, and
   activating the telematics unit backup battery;
   operating the transport refrigeration system in a second telemetry unit status
   update mode, whereby the telematics unit is powered on, when at least one of a second
   power up timer expires and the status update request is received from the host service, the
   second telemetry unit status update mode including:
   providing power from the telematics unit backup battery to the telematics
   unit,
   sending limited telemetry data to the host service.

5. The method of claim 4, the second telemetry unit status update mode also
   including:
   activating the control area network;
   receiving the limited telemetry data from the transport refrigeration system
   controller.

6. The method of claim 4, wherein the limited telemetry data includes a
   geographical location of the transport unit.
7. The method of claim 1, further comprising:
   operating the transport refrigeration system in a full null mode for powering off
   the telematics unit, the generator set, and the transport refrigeration unit when:
   at least one of a telematics unit backup battery of the transport
   refrigeration system is not active and a battery level of the telematics unit backup
   battery is below a second minimum threshold battery level,
   at least one of the transport refrigeration unit battery is not active and the
   battery level of the transport refrigeration unit battery is below the minimum
   threshold battery level.

8. The method of claim 1, further comprising:
   operating the transport refrigeration system in a full on mode for starting the
   generator set when the battery level of the transport refrigeration unit battery is above the
   minimum threshold battery level, the full on mode including:
   activating the transport refrigeration unit battery,
   activating the control area network,
   activating the ignition feedback line.

9. A transport refrigeration system comprising:
   a transport refrigeration unit including a transport refrigeration system controller
   and a refrigeration circuit, wherein the transport refrigeration system controller is
   configured to regulate an operating condition of an interior space of a transport unit of the
   transport refrigeration system;
   a telematics unit connected to the transport refrigeration system controller, the
   telematics unit configured to generate telemetry data based on an operating condition
   status of the transport refrigeration system;
   a generator set connected to the transport refrigeration unit and the telematics
   unit, the generator set includes an engine, and the generator set is configured to provide
   power to the transport refrigeration unit and the telematics unit; and
   a transport refrigeration unit battery connected to the transport refrigeration unit,
   the telematics unit and the generator set, wherein the transport refrigeration unit battery is
configured to provide power to the transport refrigeration unit and the telematics unit when the generator set is not running;

wherein the telematics unit is further configured to control a power management mode of the transport refrigeration system based on a battery level of the transport refrigeration unit battery when the generator set is not running.

10. The transport refrigeration system of claim 9, wherein the telematics unit is configured to generate the telemetry data based on the operation condition status of at least one of a door of a transport unit of the transport refrigeration system, a fuel level of the generator set, a temperature within the transport unit, an ambient temperature surrounding the transport unit, a humidity level within the transport unit, an ambient humidity surrounding the transport unit, a geographical location of the transport unit, and an engine speed data of the engine of the generator set.

11. The transport refrigeration system of claim 9, wherein the telematics unit is configured to send the telemetry data to a host service via at least one of an e-mail and a short message service text.

12. The transport refrigeration system of claim 9, wherein the telematics unit is configured to send the telemetry data to a remote server.

13. The transport refrigeration system of claim 9, further comprising a telematics unit backup battery connected to the telematics unit and configured to provide power to the telematics unit when the generator set is not running.

14. The transport refrigeration system of claim 13, wherein the generator set is configured to charge the telematics unit backup battery when the generator set is running.

15. The transport refrigeration system of claim 9, wherein the generator set is configured to charge the transport refrigeration unit battery when the generator set is running.
INTERNATIONAL SEARCH REPORT

International application No. PCT/US2013/046201

A. CLASSIFICATION OF SUBJECT MATTER

B60P 3/20(2006.01)i, B60H 1/32(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60P 3/20; B60P 3/00; B60H 1/32; B60H 1/00; B60L 1/00; F25B 27/00; B60R 16/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: transport refrigeration, power, management, generator, and battery

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td> 2012-021685 Al (CARRIER CORPORATION) 16 February 2012 See paragraphs 18-31 and figure 1.</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:
  
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"&" document member of the same patent family

Date of the actual completion of the international search

17 October 2013 (17.10.2013)

Date of mailing of the international search report

21 October 2013 (21.10.2013)

Name and mailing address of the ISA/KR

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