

wide range of aircraft operational and business processes puts additional demand on communications.

The electrical energy used to power commercial airplanes on the ground is 115Vac, 400Hz, three-phase power, and includes a neutral line. It has been possible to transfer at least a portion of the data referred to above over these power lines. In one such system, a data transfer rate across a single phase (conductor) of the three-phase system up to about 65 Mbps has been accomplished. Transferring data on all three conductors of the three-phase system could triple the data rate. However, these “power stingers” used on flight lines around the world generally are fabricated using unshielded conductors. Attempting to transfer data over all three conductors, at a data rate considered to be useful for such application results in a noisy coupling between the conductors of the three-phase system. More specifically, the reduction in data rate caused by inductive and capacitive coupling of the signal and noise between the three phases on the 400 Hz ground power system results in an adverse effect on the data rate for a broadband over power line (BPL) communication system.

#### BRIEF DESCRIPTION

In one aspect, there is provided a method for providing information by optimizing a data rate to a vehicle over a single three-phase power line utilized to provide power to the vehicle, said method comprising: assigning three separate frequency bands to three respective conductors extending between a ground power system and the vehicle, the three respective conductors forming the three-phase power line; generating carrier signals in the three separate frequency bands, wherein the three separate frequency bands are between about 2 MHz and about 80 MHz; modulating various data onto the three carrier signals to generate three transmission signals for sending the various data from the ground power system to the vehicle at frequencies within respective ones of the three separate frequency bands, wherein the frequencies for each of the three separate frequency bands do not overlap one another; switching the three transmission signals onto respective conductors of the three-phase power line; monitoring an impedance of each conductor; adjusting the frequencies for each conductor based on changes in the monitored impedance; demodulating the various data within the vehicle; providing the various data to one or more vehicle systems.

In another aspect, there is provided a data communication system comprising: a transmission medium comprising a single three-phase power line comprising a conductor associated with each respective phase; a controller operable to: assign three separate frequency bands to three respective conductors extending between a ground power system and a vehicle, the three respective conductors forming the three-phase power line; generate multiple carrier frequencies in respective one of the three separate frequency bands, wherein the three separate frequency bands are between about 2 MHz and about 80 MHz; separate data for transmission across said transmission medium into a plurality of separate data packages; modulate the plurality of separate data packages at frequencies within respective ones of the three separate frequency bands to send the plurality of separate data packages from the ground power system to the vehicle, wherein the frequencies for each of the three separate frequency bands do not overlap one another; monitor an impedance of each conductor; and adjust the frequencies for each conductor based on changes in the monitored impedance.

In yet another aspect, there is provided a system for transmission of broadband signals over a single three-phase power line, said system comprising: a three-phase power system; a three-phase power line comprising a plurality of conductors, said power line operable for transfer of three-phase power generated by said three-phase power system to a load via said conductors; a data source; a controller communicatively coupled to said data source and programmed to configure data received from said data source into data packages for transmission along said three-phase power line from a ground power system to a vehicle; a modulation signal source, said controller further configured to associate a modulation frequency range with each said conductor, a different modulation frequency range for each of the conductors such that the modulation frequency ranges do not overlap one another, wherein the modulation frequency ranges are between about 2 MHz and about 80 MHz; and a modulation device operable for modulating data packages from said controller onto one or more of said conductors using the modulation signal associated with the conductor to send the data packages from the ground power system to the vehicle, said controller programmed to assign the data packages for modulation onto a specific one of conductors based on a data rate associated with said three-phase power line, said controller further programmed to monitor an impedance of each conductor, and adjust the frequencies for each conductor based on changes in the monitored impedance.

In one aspectembodiment, a method for providing information by optimizing the data rate to a vehicle over a three-phase power line utilized to provide power to the vehicle is provided. The method includes generating carrier signals in three separate frequency bands, modulating various data onto three carrier signals to generate three transmission signals, switching the three transmission signals onto respective conductors of the three-phase power line, demodulating the various data within the vehicle, and providing the various data to one or more vehicle systems.

In another aspectembodiment, a data communication system is provided that includes a transmission medium comprising a three-phase power line comprising a conductor associated with each respective phase, a controller, and an electrical interface to couple modulated data packages onto a plurality of conductors for transmission. The controller is operable to generate multiple carrier frequencies, separate data for transmission across the transmission medium into a plurality of separate data packages, and modulate the plurality of separate data packages with a respective one of the carrier frequencies.

In still another aspectembodiment, a system for transmission of broadband signals over a three-phase power line is provided. The system includes a three-phase power system and a three-phase

power line comprising a plurality of conductors, where the power line is operable for transfer of three-phase power generated by the three-phase power system to a load via the conductors. The system further includes a data source, a controller communicatively coupled to the data source and programmed to configure data received from the data source into data packages for transmission along the three-phase power line, a modulation signal source. The controller may be further configured to associate a modulation frequency range with each conductor, a different modulation frequency range for each of conductors, and a modulation device (e.g., processing device) operable for modulating data packages from the controller onto one or more of the conductors using the modulation signal associated with the conductor. The controller is programmed to assign the data packages for modulation onto a specific one of the conductors based on a data rate associated with the three-phase power line.

In yet another ~~aspect~~embodiment, a system for transmission of broadband signals over a three-phase power line is provided where the system comprises: three-phase power system; a three-phase power line comprising a plurality of conductors, said power line operable for transfer of three-phase power generated by said three-phase power system to a load via said conductors; a data source; a controller communicatively coupled to said data source and programmed to configure data received from said data source into data packages for transmission along said three-phase power line; a modulation signal source, said controller further configured to associate a modulation frequency range with each said conductor, a different modulation frequency range for each of conductors; and a modulation device operable for modulating data packages from said controller onto one or more of said conductors using the modulation signal associated with the conductor, said controller programmed to assign the data packages for modulation onto a specific one of conductors based on a data rate associated with said three-phase power line. The controller in the system may be programmed to determine whether transmission of a specific data package requires a throughput higher than can be achieved on a single one of said conductors; if, the transmission does not require a higher throughput, delay the transmission for a predetermined period, and subsequently commence the transmission on the single one of said conductors; and if, the transmission does require a higher throughput, add at least one additional of said conductors of said three-phase power line to the transmission, and subsequently commence the transmission by separating the data package into multiple data packages and modulating the separated data package onto said conductors. Advantageously, the conductor may be is operable to: determine if a transmission data rate across one or more of said conductors was within an optimal data rate; and adjust at least one modulation frequency range

## WHAT IS CLAIMED IS:

1. A method for providing information by optimizing a data rate to a vehicle over a three-phase power line utilized to provide power to the vehicle, said method comprising:

generating carrier signals in three separate frequency bands;

modulating various data onto three carrier signals to generate three transmission  
5 signals;

switching the three transmission signals onto respective conductors of the three-phase power line;

demodulating the various data within the vehicle; and

providing the various data to one or more vehicle systems.

10 2. The method according to Claim 1 wherein generating carrier signals in three separate frequency bands comprises:

generating a first carrier signal to be within a first frequency range;

generating a second carrier signal to be within a second frequency range; and

generating a third carrier signal to be within a third frequency range.

15 3. The method according to Claim 1 wherein generating carrier signals at three separate frequencies comprises:

generating a first carrier signal to be between about 2 MHz and about 30 MHz;

generating a second carrier signal to be between about 30 MHz and about 55  
MHz; and

20 generating a third carrier signal to be between about 55 MHz and about 80 MHz.

4. The method according to Claim 1 wherein generating carrier signals at three separate frequency bands comprises dynamically selecting frequencies for the carrier signals to increase a data transmission rate across the respective conductors of the three-phase power line.

5. The method according to Claim 1 wherein generating carrier signals at three separate frequency bands comprises dynamically selecting frequencies for the carrier signals to decrease cross coupling between the respective conductors of the three-phase power line.

6. The method according to Claim 1 further comprising monitoring and trending data rates across the respective conductors of the three-phase power line.

7. The method according to Claim 6 wherein monitoring and trending data rates across the respective conductors of the three-phase power line comprises determining if a transmission data rate was within an optimal data rate, the optimal data rate either being selected by a user or determined from statistical results.

8. The method according to Claim 1 wherein modulating various data onto the three carrier signals comprises dividing the various data into three sets of data messages.

9. The method according to Claim 1 wherein generating carrier signals at three separate frequency bands comprises:

determining whether a transmission requires a throughput higher than can be achieved on a single conductor;

if, the transmission does not require a higher throughput, delaying for a predetermined period, and subsequently commencing the transmission on the single conductor; and

if, the transmission does require a higher throughput, adding at least one additional conductor of the three-phase power line to the transmission and subsequently commencing the transmission on multiple conductors.

10. The method according to Claim 9 wherein subsequently commencing the transmission on the multiple conductors comprises:

determining whether the transmission requires a throughput higher than can be achieved on two conductors;

if, the transmission does not require a higher throughput, delaying for a predetermined period, and subsequently commencing the transmission on the two conductors; and

5 if, the transmission does require a higher throughput, adding an additional conductor of the three-phase power line to the transmission and subsequently commencing the transmission on the respective conductors.

11. The method according to Claim 8 wherein commencing the transmission on the single conductor further comprises applying pulses to an unused conductors of the power line to determine at least one of an electrical load capacity and a noise capacity of the three-phase power  
10 line.

12. A data communication system comprising:

a transmission medium comprising a three-phase power line comprising a conductor associated with each respective phase;

a controller operable to:

15 generate multiple carrier frequencies;

separate data for transmission across said transmission medium into a plurality of separate data packages; and

modulate the plurality of separate data packages with a respective one of the multiple carrier frequencies; and

20 an electrical interface to couple multiple modulated data packages onto a plurality of conductors for transmission.

13. The system according to Claim 12 further comprising:

25 a second electrical interface to decouple the multiple modulated data packages from the plurality of said conductors after transmission to regenerate the plurality of separate data packages; and

a receiver to detect the separate data packages.

14. The system according to Claim 13 further comprising a processing device to combine the separate data packages into a single signal.

15. The system according to Claim 12 wherein said controller is operable to monitor and trend data rates across said transmission medium.

WHAT IS CLAIMED IS:

1. A method for providing information by optimizing a data rate to a vehicle over a single three-phase power line utilized to provide power to the vehicle, said method comprising:
  - 5 assigning three separate frequency bands to three respective conductors extending between a ground power system and the vehicle, the three respective conductors forming the three-phase power line;
  - generating carrier signals in the three separate frequency bands, wherein the three separate frequency bands are between about 2 MHz and about 80 MHz;
  - 10 modulating various data onto the three carrier signals to generate three transmission signals for sending the various data from the ground power system to the vehicle at frequencies within respective ones of the three separate frequency bands, wherein the frequencies for each of the three separate frequency bands do not overlap one another;
  - switching the three transmission signals onto respective conductors of the three-phase power line;
  - 15 monitoring an impedance of each conductor;
  - adjusting the frequencies for each conductor based on changes in the monitored impedance;
  - demodulating the various data within the vehicle;
  - providing the various data to one or more vehicle systems.
- 20 2. The method according to claim 1 wherein generating carrier signals in three separate frequency bands comprises:
  - generating a first carrier signal to be within a first frequency range;
  - generating a second carrier signal to be within a second frequency range; and
  - 25 generating a third carrier signal to be within a third frequency range.
3. The method according to claim 1 wherein generating carrier signals in three separate frequency bands comprises:
  - generating a first carrier signal to be between about 2 MHz and about 30 MHz;
  - 30 generating a second carrier signal to be between about 30 MHz and about 55 MHz; and
  - generating a third carrier signal to be between about 55 MHz and about 80 MHz.

4. The method according to claim 1 wherein generating carrier signals at three separate frequency bands comprises dynamically selecting frequencies for the carrier signals to increase a data transmission rate across the respective conductors of the three-phase power line.
- 5 5. The method according to claim 1 wherein generating carrier signals at three separate frequency bands comprises dynamically selecting frequencies for the carrier signals to decrease cross coupling between the respective conductors of the three-phase power line.
- 10 6. The method according to claim 1 further comprising monitoring and trending data rates across the respective conductors of the three-phase power line, wherein monitoring and trending data rates across the respective conductors of the three-phase power line comprises determining if a transmission data rate was within an optimal data rate range, the optimal data rate range either being selected by a user or determined from statistical results.
- 15 7. The method according to claim 1 wherein modulating various data onto the three carrier signals comprises dividing the various data into three sets of data messages.
8. The method according to claim 1 wherein generating carrier signals at three separate frequency bands comprises:
- 20 determining whether a transmission requires a throughput higher than can be achieved on a single conductor;  
when the transmission does not require a higher throughput, delaying for a predetermined period, and subsequently commencing the transmission on the single conductor; and  
when the transmission does require the higher throughput, adding at least one additional
- 25 conductor of the three-phase power line to the transmission and subsequently commencing the transmission on the multiple conductors.
9. The method according to claim 1, further comprising:  
determining that a transmission data rate across at least one of the conductors was not within
- 30 an optimal data rate range; and  
adjusting a frequency of a transmission signal on the at least one conductor such that the adjusted frequency is still within a frequency band assigned to the at least one conductor.

10. The method according to claim 8 wherein commencing the transmission on the single conductor further comprises applying pulses to an unused conductors of the power line to determine at least one of an electrical load capacity and a noise capacity of the three-phase power line.

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11. A data communication system comprising:

a transmission medium comprising a single three-phase power line comprising a conductor associated with each respective phase;

a controller operable to:

10 assign three separate frequency bands to three respective conductors extending between a ground power system and a vehicle, the three respective conductors forming the three-phase power line;

generate multiple carrier frequencies in respective one of the three separate frequency bands, wherein the three separate frequency bands are between about 2 MHz and about 80 MHz;

15 separate data for transmission across said transmission medium into a plurality of separate data packages;

modulate the plurality of separate data packages at frequencies within respective ones of the three separate frequency bands to send the plurality of separate data packages from the ground power system to the vehicle, wherein the frequencies for each of the three separate frequency

20 bands do not overlap one another;

monitor an impedance of each conductor; and

adjust the frequencies for each conductor based on changes in the monitored impedance.

12. The system according to claim 11 further comprising:

25 a second electrical interface to decouple the multiple modulated data packages from the plurality of said conductors after transmission to regenerate the plurality of separate data packages; and

a receiver to detect the separate data packages.

30 13. The system according to claim 12 further comprising a processing device to combine the separate data packages into a single signal.

14. The system according to claim 11 wherein said controller is operable to monitor and trend data rates across said transmission medium.

15. A system for transmission of broadband signals over a single three-phase power line, said system comprising:

a three-phase power system;

a three-phase power line comprising a plurality of conductors, said power line operable for transfer of three-phase power generated by said three-phase power system to a load via said conductors;

a data source;

a controller communicatively coupled to said data source and programmed to configure data received from said data source into data packages for transmission along said three-phase power line from a ground power system to a vehicle;

a modulation signal source, said controller further configured to associate a modulation frequency range with each said conductor, a different modulation frequency range for each of the conductors such that the modulation frequency ranges do not overlap one another, wherein the modulation frequency ranges are between about 2 MHz and about 80 MHz; and

a modulation device operable for modulating data packages from said controller onto one or more of said conductors using the modulation signal associated with the conductor to send the data packages from the ground power system to the vehicle, said controller programmed to assign the data packages for modulation onto a specific one of conductors based on a data rate associated with said three-phase power line, said controller further programmed to monitor an impedance of each conductor, and adjust the frequencies for each conductor based on changes in the monitored impedance.

16. The system according to claim 15 wherein said controller is programmed to:

determine whether transmission of a specific data package requires a throughput higher than can be achieved on a single one of said conductors;

when the transmission does not require a higher throughput,

delay the transmission for a predetermined period, and

subsequently commence the transmission on the single one of said conductors; and

when the transmission does require the higher throughput,

add at least one additional of said conductors of said three-phase power line to the transmission, and

subsequently commence the transmission by separating the data package into multiple data packages and modulating the separated data package onto said conductors.

17. The system according to claim 15 further comprising a receiver operable to decouple modulated signals from said conductors and combine any separated data packages into a single data signal.

5 18. The system according to claim 11 wherein to separate data for transmission, said controller is configured to route data from different data sources to separate conductors.

10 19. The system according to claim 11 wherein said controller is configured to provide predictive control changes based on at least one of use patterns, aircraft type, weather, and electrical load.