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(54) Title: SYSTEM AND METHOD FOR COMMUNICATING AN ANALOG SIGNAL BETWEEN TWO REMOTE LOCATIONS
IN AN AIRCRAFT

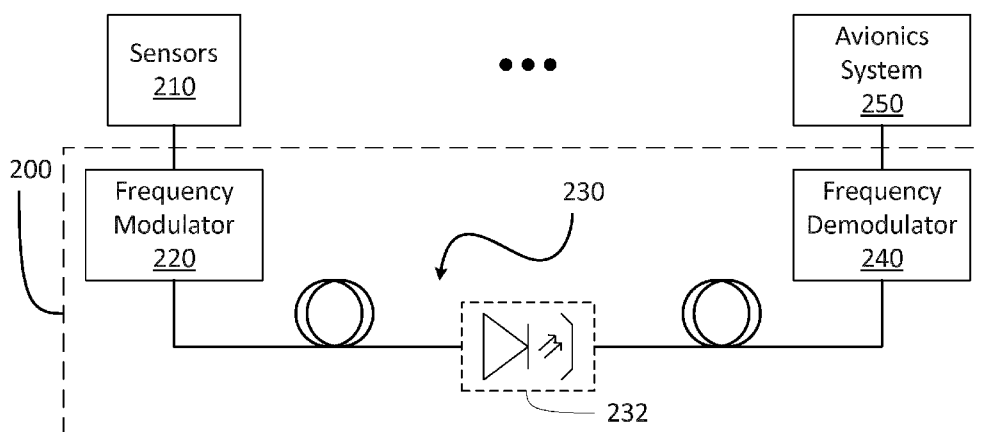


FIGURE 2

(57) Abstract: Methods and systems for communicating an analog signal between two remote locations in an aircraft are provided. A frequency modulator is located at a first location onboard the aircraft, the frequency modulator configured for converting a received analog signal to a frequency-modulated signal. A frequency demodulator is located at a second location onboard the aircraft remote from the first location onboard the aircraft, the frequency demodulator configured for converting the frequency-modulated signal to a converted analog signal substantially identical to the received analog signal. One or more conductor cables define a continuous conductive path between the frequency modulator and the frequency demodulator for conducting the frequency-modulated signal between the frequency modulator and the frequency demodulator.



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SYSTEM AND METHOD FOR COMMUNICATING AN ANALOG SIGNAL BETWEEN
TWO REMOTE LOCATIONS IN AN AIRCRAFT

Cross-Reference to Related Application(s)

[0000] This International PCT Patent Application relies for priority on U.S. Provisional Patent Application Serial No. 62/608,831 filed on December 21, 2017, the entire content of which is incorporated herein by reference.

TECHNICAL FIELD

[0001] The present disclosure relates generally to aircraft, and more specifically to data transmission onboard aircraft.

BACKGROUND

[0002] Modern aircraft use numerous sensors to monitor changes in the operating conditions and characteristics of the aircraft. Beyond the sensors used to monitor engine performance or external climate conditions, aircraft also use sensors to monitor conditions internal to the aircraft, such as cabin temperature, humidity, pressure, and the like. In many cases, the sensors used in aircraft are analog sensors, which output a voltage signal indicative of the value measured by the sensor.

[0003] However, in aircraft, as in many vehicles, the control system which makes use of the sensors are often not located proximate thereto. In such cases, the analog voltage signal produced by the sensor is carried over long stretches of wire or other conductive path until reaching the control system, causing signal degradation. Existing techniques aiming to compensate for the signal degradation rely on approximations and curve-fitting algorithms, which are often designed with a “one-size-fits-all” approach and are not tailored to the specific characteristics of the aircraft in question.

[0004] As such, there is a need for improvement.

SUMMARY

[0005] In accordance with a broad aspect, there is provided a system for communicating an analog signal between two remote locations in an aircraft. The system comprises: a frequency modulator located at a first location onboard the aircraft, the frequency modulator configured for converting a received analog signal to a frequency-modulated signal; a frequency demodulator located at a second location onboard the aircraft remote from the first location onboard the aircraft, the frequency demodulator configured for converting the frequency-modulated signal to a converted analog signal substantially identical to the received analog signal; and one or more conductor cables defining a continuous conductive path between the frequency modulator and the frequency demodulator for conducting the frequency-modulated signal between the frequency modulator and the frequency demodulator.

[0006] In some embodiments, the one or more conductor cables comprise an electrically-conductive cable.

[0007] In some embodiments, the electrically-conductive cable is a wire having a gauge of at most 24.

[0008] In some embodiments, the continuous conductive path comprises an optocoupler for electrically isolating the frequency modulator from the frequency demodulator.

[0009] In some embodiments, the frequency-modulated signal has a central frequency of approximately 500 kHz and a modulation range of approximately 100 kHz.

[0010] In some embodiments, the one or more conductor cables comprise an optically-conductive cable.

[0011] In some embodiments, the frequency modulator and the frequency demodulator are at least 10 meters apart.

[0012] In some embodiments, the frequency modulator and the frequency demodulator each comprises a substantially identical integrated circuit.

[0013] In some embodiments, the frequency modulator and the frequency demodulator are configured to operate substantially in real-time.

[0014] In some embodiments, the frequency modulator is located in a rear portion of the aircraft, and wherein the frequency demodulator is located in a front portion of the aircraft.

[0015] In accordance with another embodiment, there is provided a method for communicating an analog signal between two remote locations in an aircraft. An analog signal is received at a frequency modulator located at a first location onboard the aircraft. The analog signal is converted to a frequency-modulated signal. The frequency-modulated signal is conducted to a frequency demodulator over one or more conductor cables defining a continuous conductive path between the frequency modulator and the frequency demodulator, the frequency demodulator located at a second location onboard the aircraft remote from the first location onboard the aircraft. The frequency-modulated signal is converted to a converted analog signal substantially identical to the received analog signal.

[0016] In some embodiments, conducting the frequency-modulated signal to a frequency demodulator over one or more conductor cables comprises conducting the frequency-modulated signal over an electrically-conductive cable.

[0017] In some embodiments, the electrically-conductive cable is a wire having a gauge of at most 24.

[0018] In some embodiments, conducting the frequency-modulated signal comprises electrically isolating the frequency modulator from the frequency demodulator using an optocoupler.

[0019] In some embodiments, converting the analog signal to a frequency-modulated signal comprises producing the frequency-modulated signal having a central frequency of approximately 500 kHz and a modulation range of approximately 100 kHz.

[0020] In some embodiments, conducting the frequency-modulated signal to a frequency demodulator over one or more conductor cables comprises conducting the

frequency-modulated signal over an optically-conductive cable.

[0021] In some embodiments, conducting the frequency-modulated signal comprises conducting the frequency-modulated signal at least 10 meters over the one or more conductor cables.

[0022] In some embodiments, steps are performed substantially in real-time.

[0023] In some embodiments, conducting the frequency-modulated signal comprises conducting the frequency-modulated signal from a rear portion of the aircraft to a front portion of the aircraft.

[0024] Features of the systems, devices, and methods described herein may be used in various combinations, and may also be used for the system and computer-readable storage medium in various combinations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Further features and advantages of embodiments described herein may become apparent from the following detailed description, taken in combination with the appended drawings, in which:

[0026] Figure 1 is a diagram of an example aircraft including a signal transmission system as disclosed herein.

[0027] Figure 2 is a diagram of the example signal transmission system.

[0028] Figures 3A-C are example signal diagrams for the signal transmission system of Figure 2.

[0029] Figure 4 is a flowchart of a method for communicating an analog signal between two remote locations according to an embodiment.

[0030] Figure 5 is a circuit diagram of an example implementation of the signal transmission system of Figure 2.

[0031] It will be noted that throughout the appended drawings, like features are

identified by like reference numerals.

DETAILED DESCRIPTION

[0032] With reference to Figure 1, an aircraft 100, having a fuselage 110, is equipped with a pair of wings 140, engines 150, and a tail 160. Aircraft 100 may be any suitable aircraft such as corporate, private, commercial or any other type of aircraft. For example, aircraft 100 may be a narrow-body, twin engine jet airliner. Aircraft 100 may be a fixed wing or a rotary wing aircraft. The fuselage 110 has a cockpit 120, which can be positioned at any suitable location on the aircraft 100, for example at a front portion of the fuselage 110. The cockpit 120 is configured for accommodating one or more pilots who control the aircraft 100 by way of one or more operator controls (not illustrated). The operator controls can include any suitable number of pedals, yokes, steering wheels, centre sticks, flight sticks, levers, knobs, switches, and the like.

[0033] In addition, the aircraft 100 is provided with one or more sensors 210. The sensors 210 can include temperature sensors, position sensors, humidity sensors, pressure sensors, brightness sensors, windspeed sensors, and the like. In some embodiments, the sensors 210 are configured for producing analog voltage signals, for example via transducers. The analog voltage signals produced by the sensors 210 encode information in the voltage level of the analog voltage signals. For example, a temperature sensor can be configured to produce voltages between 0 V and 5 V indicative of temperatures ranging from 0 C to 50 C. At least some of the sensors 210 are located in a rear portion of the fuselage 110, for example in a cabin of the aircraft 110, where passengers may be seated. Other sensors 210 can be provided in the wings 140, in other portions of the fuselage, for example in a cargo bay, in the tail 160, or in any other portion of the aircraft 100.

[0034] The aircraft 100 is also provided with an avionics system 250. The avionics system 250 is configured for acquiring a variety of data from a number of different sensors and for providing useful information to operators of the aircraft 100 based on the data. The avionics system 250 can be composed of any number of computing systems, processing systems, communication and routing systems, and the like, as appropriate. The avionics system 250 is communicatively coupled to the sensors 210 via one or more conductive

paths which permit the sensors 210 to send signals to the avionics system 250, as described hereinbelow. The conductive path is composed of one or more conductive cables, which can include electrically-conductive cables, for example copper wires, optically-conductive cables, for example optical fibers, or any suitable combination thereof.

[0035] In certain embodiments, the avionics system 250 is located in a front portion of the fuselage 110, proximate the cockpit 120 and at a location remote from at least some of the sensors 210. The distance between the sensors 210 and the avionics system 250 can be more than 5 meters, more than 10 meters, more than 20 meters, more than 50 meters, or any other suitable distance. For example, the distance is between 5 and 25 meters, between 5 and 50 meters, between 5 and 100 meters, or any other suitable distance. Additionally, in some embodiments, the conductive path linking the sensors 210 to the avionics system 250 is longer than the straight-line distance between the sensors 210 and the avionics system 250. For example, the conductive path is positioned to avoid or bypass other structural elements located in the fuselage 110 of the aircraft 100. Thus, the length of the conductive path linking the sensors 210 and the avionics system 250 can be more than 5 meters, more than 10 meters, more than 20 meters, more than 50 meters, more than 100 meters, between 5 and 25 meters, between 5 and 50 meters, between 5 and 100 meters, or any other suitable distance.

[0036] With reference to Figure 2, there is shown a transmission system 200 for use in a vehicle, for example the aircraft 100. Although the present discussion focuses primarily on aircraft, it should be noted that the transmission system 200 described herein, and other associated systems or methods, can be applied to any other mobile platforms (e.g., vehicles). The transmission system 200 is communicatively coupled to the sensors 210 and the avionics system 250 for providing the conductive path which allows the avionics systems 250 to obtain data produced by the sensors 210. As detailed hereinbelow, the transmission system 200 converts analog voltage signals received from the sensors 210 into frequency signals via frequency modulation, transmits the frequency signals over the conductive path, then demodulates the signal proximate the avionics system 250 to provide substantially identical facsimiles of the analog voltage signals produced by the sensors 210 to the avionics system 250.

[0037] The transmission system 200 comprises a frequency modulator 220, a

conductive path 230, and a frequency demodulator 240. The frequency modulator 220 is communicatively coupled to the frequency demodulator 240 via the conductive path 230. The conductive path 230 can include electrically-conductive cables, for example copper wires, optically-conductive cables, for example optical fibers, or any suitable combination thereof. In some embodiments, the conductive path 230 includes one or more isolators 232 which are used to electrically isolate the frequency modulator 220 from the frequency demodulator 240. For example, one or more optocouplers are used to separate a first electrically-conductive cable from a second electrically-conductive cable. Other types of isolators 232 are also considered. The isolators 232 can be located at any suitable location along the conductive path 230, and at any suitable location within the aircraft 100. For example, the isolators 232 can be located proximate the frequency modulator 220, proximate the frequency demodulator 240, or at some point intermediate the frequency modulator 220 and the frequency demodulator 240. The conductive path 230 can be composed of any suitable number of parts, be disposed in any suitable fashion within the aircraft 100, and can be of any suitable length. The conductive path 230 may be generally termed “continuous” insofar as the conductive path 230 defines an uninterrupted passage for an electrical, optical, or other suitable signal. As used herein, “continuous conductive path” does not preclude elements which transform or process a signal carried thereon.

[0038] With additional reference to Figures 3A-C, the frequency modulator 220 is configured for receiving analog voltage signals, for example the analog voltage signal 302, from the sensors 210. The frequency modulator 220 can be communicatively coupled to the sensors 210 in any suitable fashion, for example via one or more conductive cables. The frequency modulator 220 can be configured for receiving analog voltage signals within a particular voltage range, for example 0–5 V, as appropriate. The frequency modulator 220 then transforms the analog voltage signal 302 into one or more frequency signals, for instance the frequency signal 304, via frequency modulation. In some embodiments, the frequency modulator 220 produces a carrier wave having a suitable carrier frequency, and modulates the frequency of the carrier wave within a modulation range to encode in the carrier wave the information provided by the sensors 210 in the analog voltage signal 302. For example, the carrier wave has a central frequency of 500 kHz, and the carrier wave is modulated within a 50 kHz range about the central frequency. Other implementations, using other central frequencies and modulation ranges, are also considered. For example,

the frequency modulator 220 produces a series of pulse trains which are used to encode the data from the sensors 210.

[0039] Once the frequency signal 304 is produced by the frequency modulator 220, the frequency signal 304 is conducted to the frequency demodulator 240 over the conductive path 230 via the conductor cables and the isolator 232, when applicable. In certain embodiments, the conductive path 230 includes various signals processing devices, such as amplifiers, filters, and the like, for preserving the integrity of the frequency signals as they are conducted over the conductive path 230.

[0040] The frequency demodulator 240 is configured for receiving the frequency signal 304 produced by the frequency modulator 220 and conducted over the conductive path 230. The frequency demodulator 240 then demodulates the frequency signal 304 to produce converted analog voltage signals which are substantially identical facsimiles of the analog voltage signals originally produced by the sensors 210, for instance the converted analog signal 306. In some embodiments, the frequency demodulator 240 includes various signal processing modules for processing the frequency signal 304 and/or the converted analog signal 306, for example one or more filters, amplifiers, and the like. As used herein, the expression “substantially identical” should be understood as meaning “generally the same” without excluding reasonable approximations. For example, the converted analog signal 306 can be a facsimile of the analog signal 212 that is somewhat distorted, clipped, compressed, or altered in any way, but still provides a reasonable approximation of the analog signal 302.

[0041] Long transmission paths can produce especially significant signal losses in low-frequency or direct current (DC) analog voltage signals, including those produced by the sensors 210. For example, the resistivity of a long transmission path can produce Ohmic losses, while inductive and/or capacitive characteristics can cause signal distortion, and the like. By conducting the frequency signals over the conductive path 230 instead of the analog voltage signals produced by the sensors 210, at least some of the signal degradation inherent to the conductive path can be avoided. Although the conductive path 230 may still effect some amplitude degradation in the frequency signal 304 during transmission over the conductive path, because the data obtained from the sensors 210 is instead encoded in the frequency modulation of the frequency signal 304, there is little-to-

no impact on the fidelity of the data after conduction through the conductive path 230.

[0042] In addition, transmitting the frequency signals over the conductive path 230 can also permit communication between portions of the aircraft that operate over different power regimes, especially when the isolators 232 are used. It should also be noted that the transmission system 200 can also be used over relatively short distances but through environments that are subjected to high levels of electrical noise. For instance, the carrier wave frequency can be selected to avoid interference or noise collection.

[0043] In this fashion, the transmission system 200 can provide, at the output of the frequency demodulator 240, a high-fidelity analog voltage signal 306 which is substantially identical to the analog voltage signal 302 produced by the sensors 210. In addition, because the frequency signal 304 is an analog signal, they can be modulated and demodulated without the need for analog-to-digital/digital-to-analog conversion, thereby not requiring any synchronization schemes or data registration. Moreover, in some embodiments the frequency signal 304 can be conducted over smaller gauge wire than would traditionally be used for conducting the analog voltage signals. For example, the conductive path 230 can use 24 gauge wire, 26 gauge wire, 28 gauge wire, or a gauge value within any suitable range, for example 24 to 28, or any other suitable gauge of wire.

[0044] In some embodiments, the frequency modulator 220 and/or the frequency demodulator 240 are implemented using analog circuit means, including one or more resistors, capacitors, inductors, transistors, and the like. In other embodiments, the frequency modulator 220 and/or the frequency demodulator 240 are implemented using one or more integrated circuits (ICs). For example, the frequency modulator 220 and/or the frequency demodulator 240 are implemented using one or more field-programmable gate arrays (FPGAs), one or more application-specific integrated circuits (ASICs), or any suitable combination of previously-mentioned elements. In some embodiments, both the frequency modulator 220 and the frequency demodulator 240 are implemented using separate copies of a common integrated circuit.

[0045] With reference to Figure 4, there is provided a method 400 for communicating an analog signal between two remote locations in an aircraft, for example the aircraft 100. At step 402, an analog signal is received at a frequency modulator, for example the

frequency modulator 220, which is located at a first location onboard the aircraft 100. The analog signal can be one of the analog voltage signals produced by the sensors 210, and the frequency modulator 220 can be located proximate the sensors 210, for example in a cabin or cockpit of the aircraft 100.

[0046] At step 404, the analog signal is converted to a frequency-modulated signal, for example by the frequency modulator 220. The frequency-modulated signal can use any suitable carrier signal and carrier frequency, and have any suitable modulation range about the carrier frequency.

[0047] At step 406, the frequency-modulated signal is conducted to a frequency demodulator, for example the frequency demodulator 240, which is located at a second location onboard the aircraft 100 remote from the first location. The frequency demodulator 240 can be located proximate the avionics system 250, for example near or proximate to the cockpit 120 of the aircraft 100.

[0048] At step 408, the frequency-modulated signal is converted to a converted analog signal which is substantially identical to the analog signal received at step 402, for example from the sensors 210.

[0049] It should be noted that the method 400 can be performed substantially in real-time, so that analog voltage signals produced by the sensors 210 are frequency-modulated and conducted to the frequency demodulator 240, and ultimately to the avionics system 250, in real-time.

[0050] With reference to Figure 5, there is shown a circuit diagram of an implementation of the transmission system 200. The sensor 210 is connected to the frequency modulator 220, which can be powered by a power source 502. In some embodiments, the frequency modulator 220 is implemented via a ADVFC32SH voltage/frequency converter, manufactured by Analog Devices Inc.TM. The frequency modulator 220 is connected to the frequency demodulator 240 via the conductive path 230, which can include an isolator 232, for example an optocoupler. The frequency demodulator 240 can be powered by a power source 504, and can also be implemented via a separate ADVFC32SH voltage/frequency converter. The frequency demodulator 240 can then supply the converted analog signal to the avionics system 250.

[0051] In addition, the frequency modulator 220 and the frequency demodulator 240 can be configured to operate multiple channels. For example, each of the sensors 210 can send analog voltage signals to the frequency modulator 220 along different wires or cables, and the frequency modulator assigns different carrier frequencies to each of the sensors 210 so they can be transmitted simultaneously, either on one or more shared conductive paths 230, or each on a separate conductive path, as appropriate. The frequency demodulator 240 can then be provided with various filters to differentiate the frequency signals produced by the frequency modulator 220, and provide each of the converted analog signals to the avionics system 250.

[0052] Various aspects of the methods and systems for communicating an analog signal between two remote locations disclosed herein, as well as the aircraft itself, may be used alone, in combination, or in a variety of arrangements not specifically discussed in the embodiments described in the foregoing and is therefore not limited in its application to the details and arrangement of components set forth in the foregoing description or illustrated in the drawings. For example, aspects described in one embodiment may be combined in any manner with aspects described in other embodiments. Although particular embodiments have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects. The scope of the following claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest reasonable interpretation consistent with the description as a whole.

CLAIMS:

1. A system for communicating an analog signal between two remote locations in an aircraft, comprising:

a frequency modulator located at a first location onboard the aircraft, the frequency modulator configured for converting a received analog signal to a frequency-modulated signal;

a frequency demodulator located at a second location onboard the aircraft remote from the first location onboard the aircraft, the frequency demodulator configured for converting the frequency-modulated signal to a converted analog signal substantially identical to the received analog signal; and

one or more conductor cables defining a continuous conductive path between the frequency modulator and the frequency demodulator for conducting the frequency-modulated signal between the frequency modulator and the frequency demodulator.

2. The system of claim 1, wherein the one or more conductor cables comprise an electrically-conductive cable.

3. The system of claim 2, wherein the electrically-conductive cable is a wire having a gauge of at most 24.

4. The system of any one of claims 1 to 3, wherein the continuous conductive path comprises an optocoupler for electrically isolating the frequency modulator from the frequency demodulator.

5. The system of any one of claims 1 to 4, wherein the frequency-modulated signal has a central frequency of approximately 500 kHz and a modulation range of approximately 100 kHz.

6. The system of any one of claims 1 to 5, wherein the one or more conductor cables comprise an optically-conductive cable.

7. The system of any one of claims 1 to 6, wherein the frequency modulator and the frequency demodulator are at least 10 meters apart.

8. The system of any one of claims 1 to 7, wherein the frequency modulator and the frequency demodulator each comprises a substantially identical integrated circuit.

9. The system of any one of claims 1 to 8, wherein the frequency modulator and the frequency demodulator are configured to operate substantially in real-time.

10. The system of any one of claims 1 to 9, wherein the frequency modulator is located in a rear portion of the aircraft, and wherein the frequency demodulator is located in a front portion of the aircraft.

11. A method for communicating an analog signal between two remote locations in an aircraft, comprising:

receiving an analog signal at a frequency modulator located at a first location onboard the aircraft;

converting the analog signal to a frequency-modulated signal;

conducting the frequency-modulated signal to a frequency demodulator over one or more conductor cables defining a continuous conductive path between the frequency modulator and the frequency demodulator, the frequency demodulator located at a second location onboard the aircraft remote from the first location onboard the aircraft; and

converting the frequency-modulated signal to a converted analog signal substantially identical to the received analog signal.

12. The method of claim 11, wherein conducting the frequency-modulated signal to a frequency demodulator over one or more conductor cables comprises conducting the frequency-modulated signal over an electrically-conductive cable.

13. The method of claim 12, wherein the electrically-conductive cable is a wire having a gauge of at most 24.

14. The method of any one of claims 11 to 13, wherein conducting the frequency-modulated signal comprises electrically isolating the frequency modulator from the frequency demodulator using an optocoupler.

15. The method of any one of claims 11 to 14, wherein converting the analog signal to a frequency-modulated signal comprises producing the frequency-modulated signal having a central frequency of approximately 500 kHz and a modulation range of approximately 100 kHz.

16. The method of any one of claims 11 to 15, wherein conducting the frequency-modulated signal to a frequency demodulator over one or more conductor cables comprises conducting the frequency-modulated signal over an optically-conductive cable.

17. The method of any one of claims 11 to 16, wherein conducting the frequency-modulated signal comprises conducting the frequency-modulated signal at least 10 meters over the one or more conductor cables.

18. The method of any one of claims 11 to 17, wherein steps are performed substantially in real-time.

19. The method of any one of claims 11 to 18, wherein conducting the frequency-modulated signal comprises conducting the frequency-modulated signal from a rear portion of the aircraft to a front portion of the aircraft.

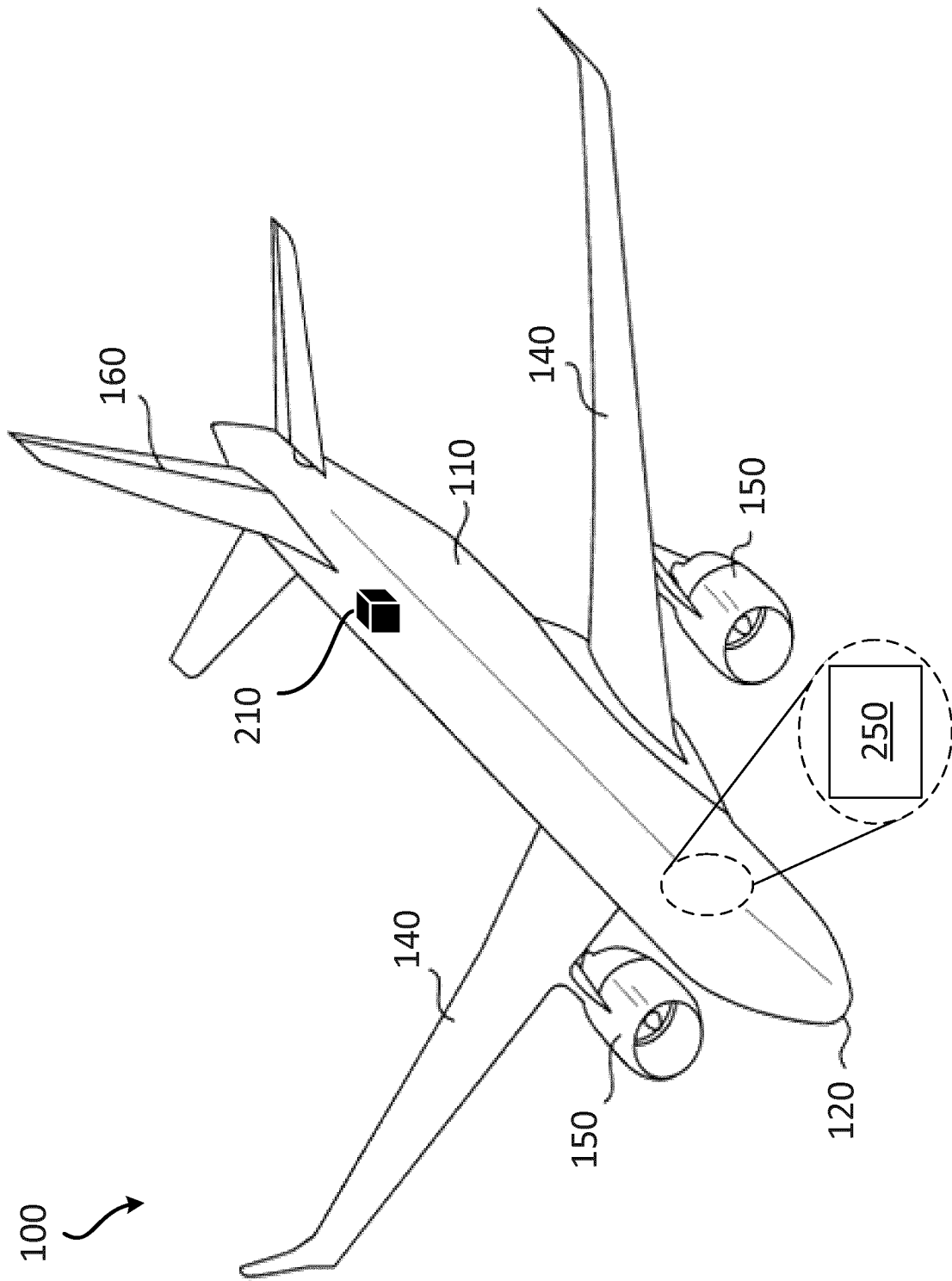


FIGURE 1

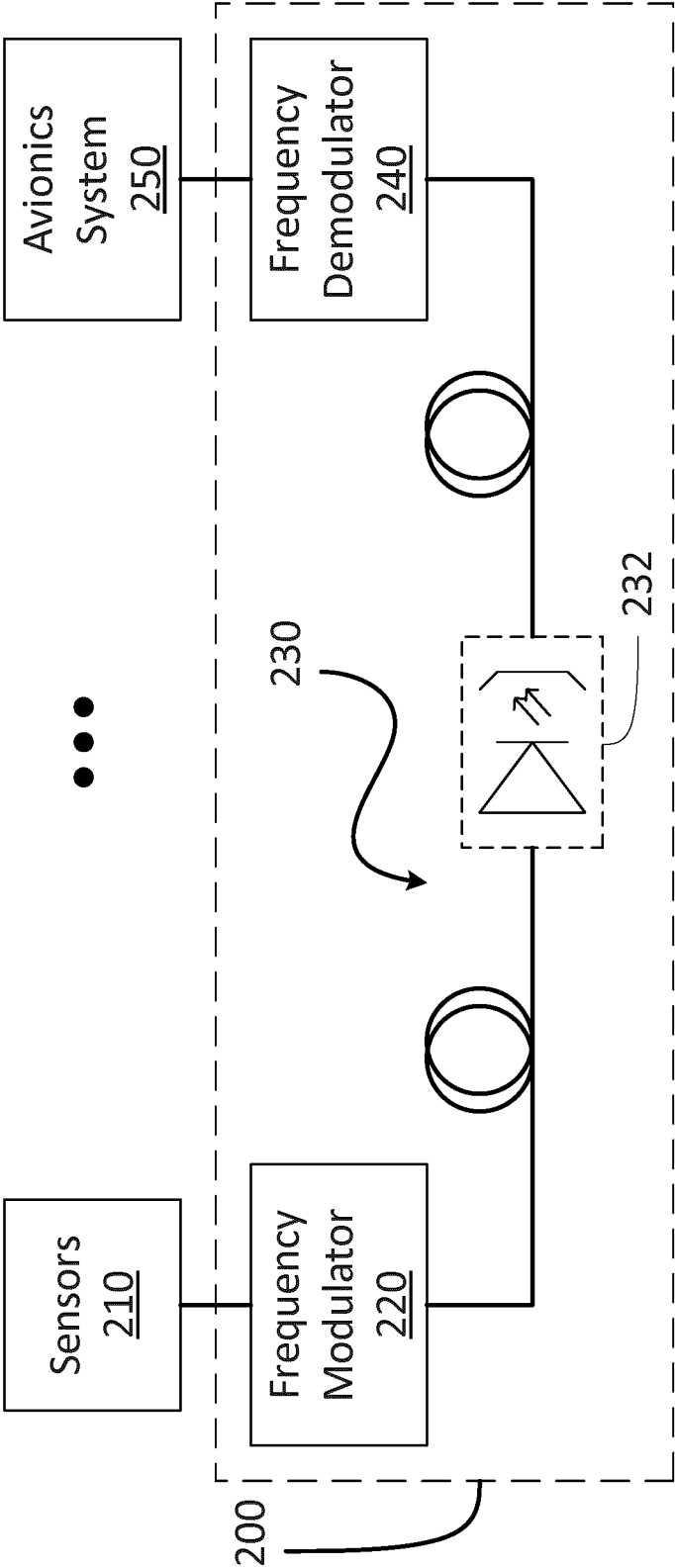


FIGURE 2

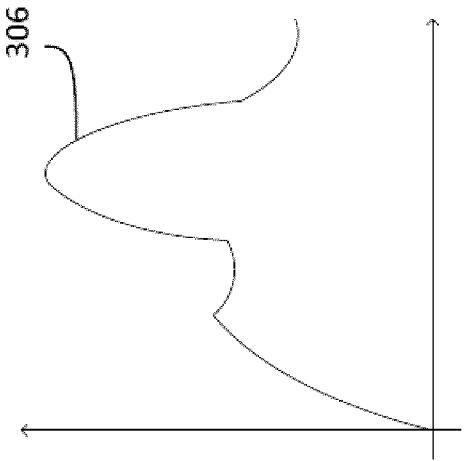


FIGURE 3A

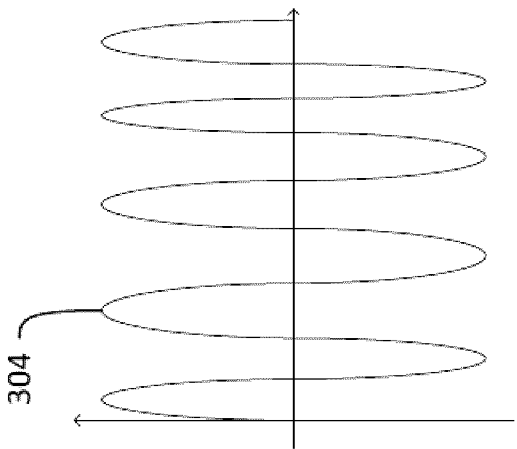


FIGURE 3B

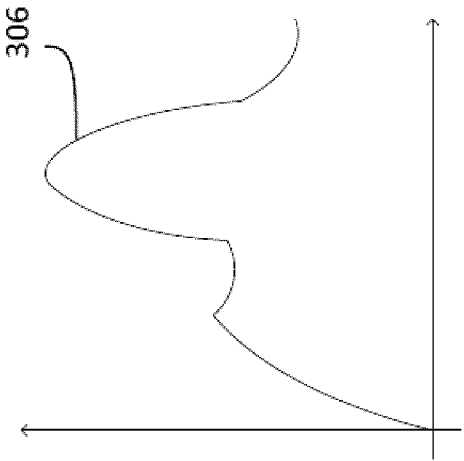


FIGURE 3C

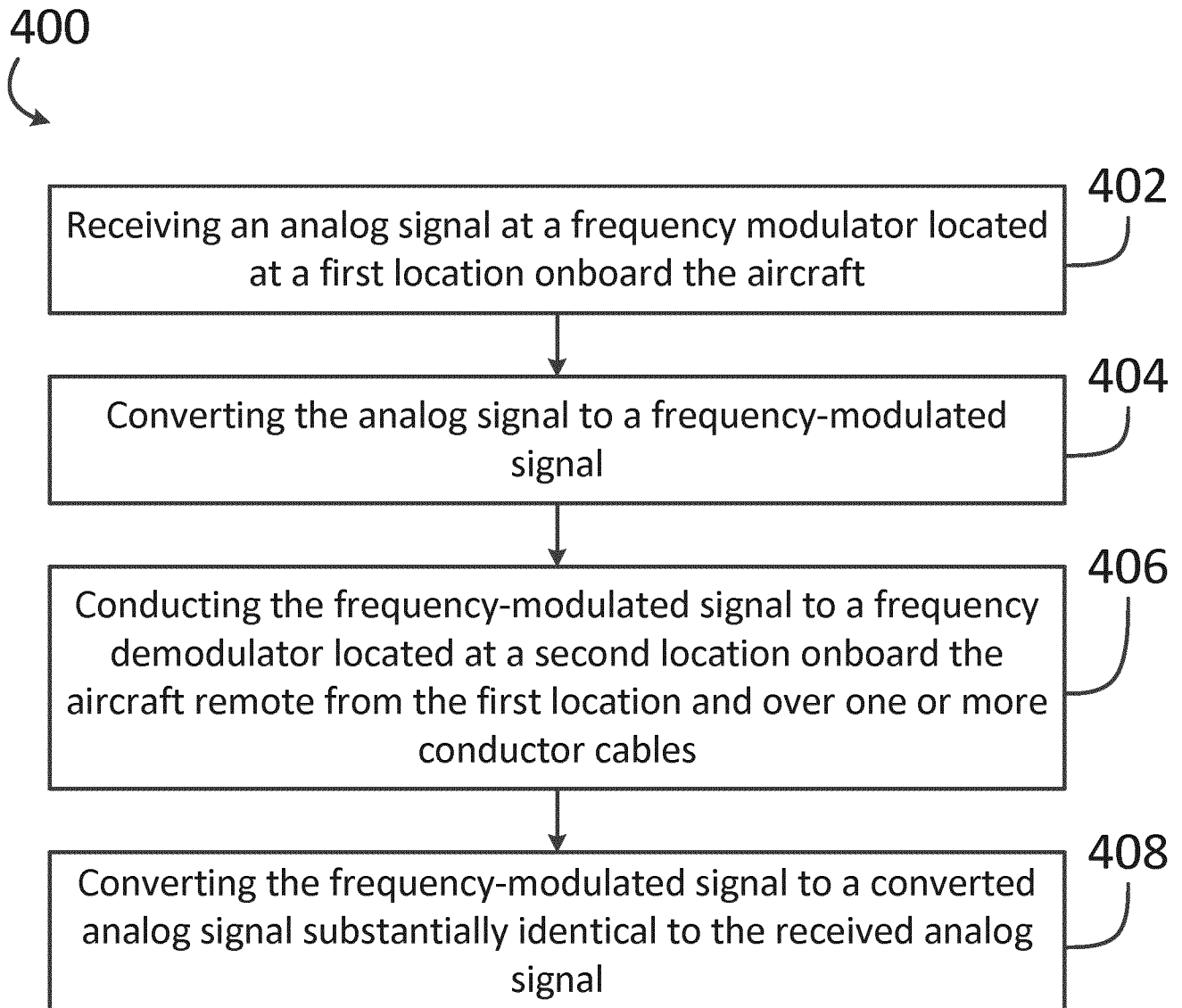


FIGURE 4

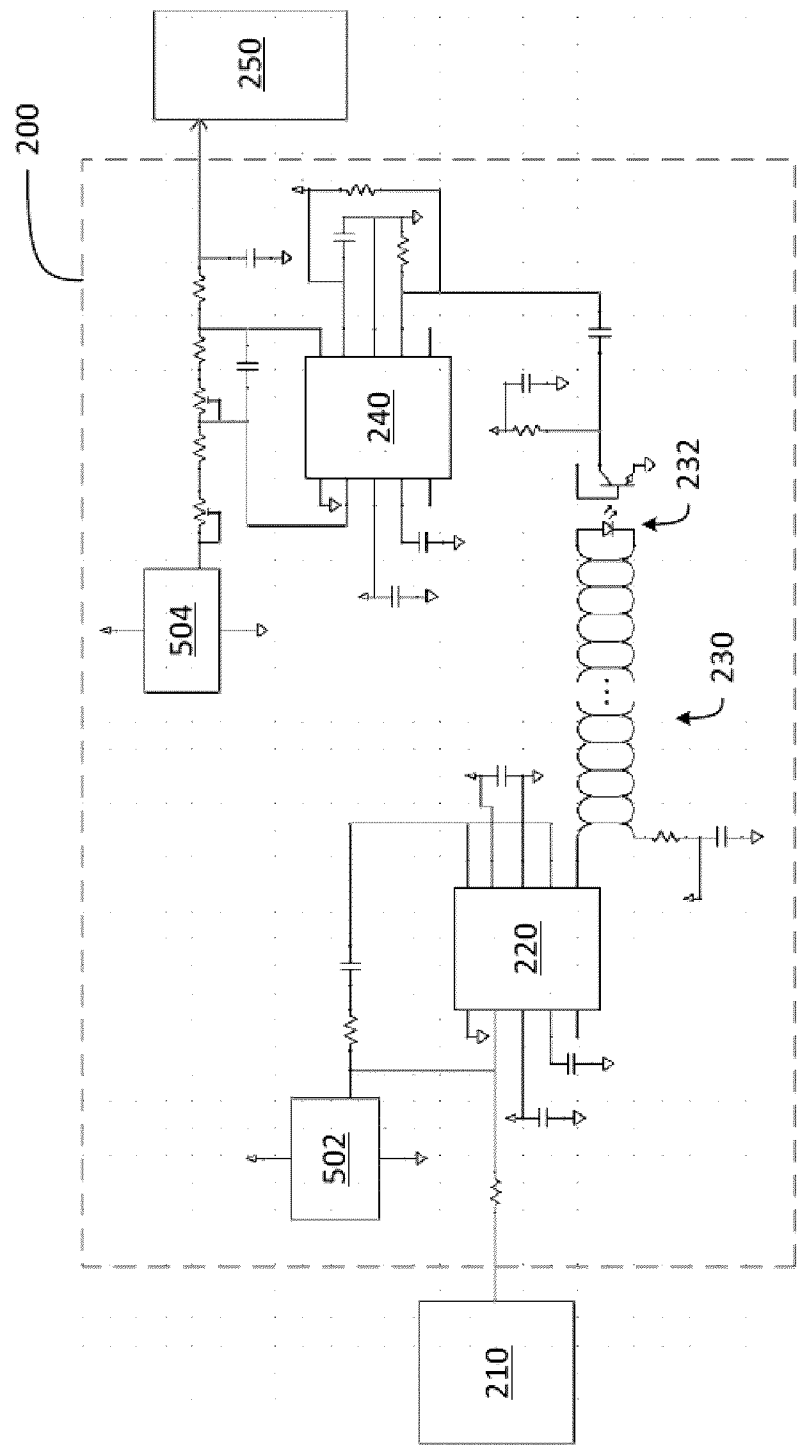


FIGURE 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CA2018/051612

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **H04B 14/00** (2006.01), **B64D 45/00** (2006.01), **B64D 47/00** (2006.01), **H04B 10/548** (2013.01),
H04B 3/02 (2006.01)

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)

IPC (2006.01): H04B 14/00, B64D 45/00, B64D 47/00, H04B 3/02

IPC (2013.01): H04B 10/548

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

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

Database: Questel Orbit, Canadian Patent Database, Google

Keywords: aircraft+, airplane+, flight?, frequenc+, modulator?, demodulator?, analog, signal?, cable?, modulation?, convert+, communication?, optocoupler?, opto-coupler?, opto-isolator?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2011/0188862 A1 (Fuss et al.), 04 August 2011 (04-08-2011) *paragraphs [0002], [0017], [0076], [0077], [0080], [0086] *Figures 1-3	1-3, 5-13, 15-19 4, 14
Y	US 4,700,379 (Ingebright), 13 October 1987 (13-10-1987) *Abstract *column 2 lines 54-60, column 3 lines 23-31 *Figure 1	4, 14
A	WO 2013/050260 A1 (Bock et al.), 11 April 2013 (11-04-2013) *whole document	1-19
A	US 2006/0141930 A1 (Keen et al.), 29 June 2006 (29-06-2006) *whole document	1-19

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier application or patent but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	"T" "X" "Y" "&"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art document member of the same patent family
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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