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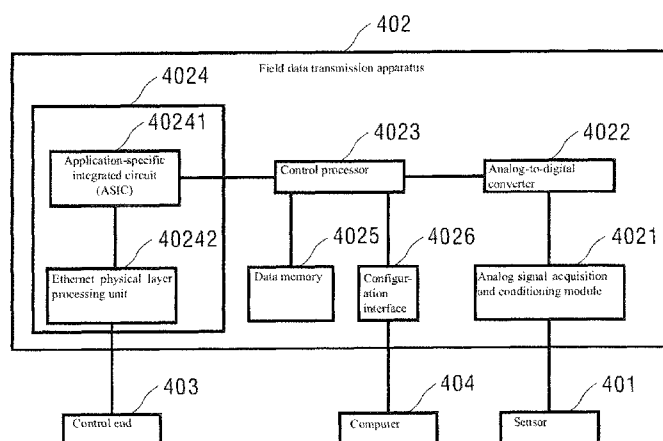
(54) **Title:** FIELD DATA TRANSMISSION APPARATUS, METHOD AND SYSTEM

Fig. 4

(57) **Abstract:** The present invention provides a field data transmission apparatus, method and system. The apparatus comprises: an analog signal acquisition and conditioning module, an analog-to-digital converter, a control processor and a Profinet interface, wherein the analog signal acquisition and conditioning module is configured to receive field data that is in the form of an analog signal and sent by an external sensor, and send the field data that is in the form of an analog signal to the analog-to-digital converter; the analog-to-digital converter is configured to convert the received field data that is in the form of an analog signal into field data that is in the form of a digital signal and then send the converted field data to the control processor; the control processor is configured to process the received field data that is in the form of a digital signal and then send the processed field data to the Profinet interface; and the Profinet interface is configured to send the received field data that is in the form of a digital signal to an external control end over an industrial Ethernet. The present solution can improve the quality of data transmission.



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DESCRIPTION**FIELD DATA TRANSMISSION APPARATUS, METHOD AND SYSTEM****5 TECHNICAL FIELD**

The present invention relates to the automation field and, in particular, to a field data transmission apparatus, method and system.

BACKGROUND

10 With the development of computer technologies, computer technologies have been widely applied to industrial production to promote the automation process of industrial production. In industrial production, field data comprising a running condition of an industrial production field device is acquired by a front-end sensor, the field data acquired by the front-end sensor is sent to a control end via a data transmission apparatus, and the control
15 end adjusts and controls the industrial production field device according to the received field data.

At present, in the process of realizing industrial production automation, an analog signal is transmitted between the front-end sensor and the data transmission apparatus, and the data transmission apparatus is connected to the control end via some standard PC interfaces
20 so as to send the field data acquired by the front-end sensor to the control end.

With regard to the data transmission apparatus provided in the prior art for realizing industrial production automation process, since the data transmission apparatus is connected to the control end via some standard PC interfaces, while the PC interfaces are not suitable for long-distance transmission, the data transmission apparatus is required to be arranged at
25 one side close to the control end, and thus the data transmission apparatus is distant from the front-end sensor in the industrial production field. The field data that is in the form of an analog signal and sent by the front-end sensor to the data transmission apparatus then needs long-distance transmission, and, under the influence of interference sources around a transmission line, interference of the field data that is in the form of an analog signal will occur;
30 in addition, attenuation of the field data due to the long-distance transmission will occur, and accordingly when data is transmitted via the data transmission apparatus provided in the prior art, the quality of data transmission is poor.

SUMMARY

35 The embodiments of the present invention provide a field data transmission apparatus, method and system, which can improve the quality of data transmission.

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The embodiments of the present invention provide a field data transmission apparatus, comprising:

an analog signal acquisition and conditioning module, an analog-to-digital converter, a control processor and a Profinet interface, wherein the Profinet interface accesses an industrial Ethernet;

the analog signal acquisition and conditioning module is configured to receive field data that is in the form of an analog signal and sent by an external sensor, and, after conditioning the field data that is in the form of an analog signal, send the conditioned field data to the analog-to-digital converter;

the analog-to-digital converter is configured to convert the received field data that is in the form of an analog signal into field data that is in the form of a digital signal and then send the converted field data to the control processor;

the control processor is configured to process the received field data that is in the form of a digital signal and then send the processed field data to the Profinet interface; and

the Profinet interface is configured to send the received field data that is in the form of a digital signal to an external control end over the industrial Ethernet.

In one preferred embodiment of a field data transmission apparatus,

the Profinet interface comprises: a packaging processing unit and an Ethernet physical layer processing unit;

wherein the packaging processing unit is configured to perform packaging processing on the field data that is in the form of a digital signal and sent by the control processor, send the packaged field data that is in the form of a digital signal to the Ethernet physical layer processing unit, and control the sending process of the Ethernet physical layer processing unit; and

the Ethernet physical layer processing unit is configured to send the packaged field data that is in the form of a digital signal to the control end over the industrial Ethernet.

In another preferred embodiment of a field data transmission apparatus,

the packaging processing unit comprises: an independently arranged application-specific integrated circuit (ASIC);

or,

the packaging processing unit comprises: an embedded real-time unit or a field programmable gate array (FPGA) integrated inside the control processor.

In yet another preferred embodiment of a field data transmission apparatus,

the field data transmission apparatus further comprises: a power supply module;

wherein the power supply module is connected to the industrial Ethernet and configured to receive AC power or DC power transmitted over the industrial Ethernet, and convert the

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received AC power or DC power into available DC power or AC power for power supply.

In yet another preferred embodiment of a field data transmission apparatus,

the field data transmission apparatus further comprises: a configuration interface;

wherein the configuration interface is connected to the control processor and configured

5 to receive configuration information sent by an external computer, and send the configuration information to the control processor; and

the control processor further controls, according to the received configuration information, the analog-to-digital converter to perform the conversion.

In yet another preferred embodiment of a field data transmission apparatus,

10 the field data transmission apparatus further comprises: data memory;

wherein the control processor is further configured to store the field data that is in the form of a digital signal in the data memory, and send the field data that is in the form of a digital signal in the data memory to the control end or computer when receiving an access instruction from the control end or computer; and

15 the data memory is configured to store the field data that is in the form of a digital signal.

The embodiments of the present invention also provide a method for performing field data transmission using any one of the field data transmission apparatuses above, wherein the field data transmission apparatus is disposed on a data acquisition field in advance, and the method comprises:

20 receiving, by using the analog signal acquisition and conditioning module, field data that is in the form of an analog signal and sent by an external sensor, and conditioning the field data that is in the form of an analog signal;

converting, by using the analog-to-digital converter, the conditioned field data that is in the form of an analog signal into field data that is in the form of a digital signal;

25 processing, by using the control processor, the field data that is in the form of a digital signal; and

sending, by using the Profinet interface, the received field data that is in the form of a digital signal to an external control end over an industrial Ethernet.

In another preferred embodiment of a data transmission method,

30 the method further comprises: when the field data transmission apparatus comprises a power supply module, the power supply module receives AC power or DC power transmitted over the industrial Ethernet, and converts the received AC power or DC power into available DC power or AC power for power supply.

The embodiments of the present invention also provide a field data transmission system, 35 comprising:

a sensor, a control end and any one of the field data transmission apparatuses provided

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in the embodiments above, the sensor and the field data transmission apparatus being both arranged in a data acquisition field, wherein

the sensor is configured to acquire field data and send the field data that is in the form of an analog signal to the field data transmission apparatus; and

the control end is configured to receive, over an industrial Ethernet, field data that is in the form of a digital signal and sent by the field data transmission apparatus via a Profinet interface.

In another preferred embodiment of a data transmission system,

the control end comprises: a programmable logic controller (PLC) or an industrial PC.

The embodiments of the present invention provide a field data transmission apparatus, method and system, wherein an analog signal acquisition and conditioning module receives field data that is in the form of an analog signal and sent by an external sensor; an analog-to-digital converter converts the field data that is in the form of an analog signal into field data that is in the form of a digital signal; and after a control processor processes the field data that is in the form of a digital signal, a Profinet interface sends the processed field data that is in the form of a digital signal to an external control end over an industrial Ethernet. Since the Profinet interface can implement long-distance transmission of digital signals, the field data transmission apparatus can be arranged at one side close to the sensor, and thus the sensor sending an analog signal to the field data transmission apparatus uses short-distance transmission, which can improve the quality of data transmission.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a field data transmission apparatus provided in one embodiment of the present invention;

Fig. 2 is a schematic diagram of a field data transmission system provided in one embodiment of the present invention;

Fig. 3 is a flow chart of a field data transmission method provided in one embodiment of the present invention;

Fig. 4 is a schematic diagram of a field data transmission system provided in another embodiment of the present invention; and

Fig. 5 is a flow chart of a field data transmission method provided in another embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The technical solutions in the embodiments of the present invention will be clearly and

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completely described below in conjunction with the drawings in the embodiments of the present invention. The described embodiments represent only some rather than all of the embodiments of the present invention. All other examples obtained by a person skilled in the art based on the embodiment of the present invention without making any inventive effort all fall within the scope of protection of the present invention.

As shown in Fig. 1, one embodiment of the present invention provides a field data transmission apparatus, comprising: an analog signal acquisition and conditioning module 101, an analog-to-digital converter 102, a control processor 103 and an industrial Ethernet (Profinet) interface 104, wherein the Profinet interface 104 is connected to an industrial Ethernet;

the analog signal acquisition and conditioning module 101 is configured to receive field data that is in the form of an analog signal and sent by an external sensor, and, after conditioning the field data that is in the form of an analog signal, send the conditioned field data to the analog-to-digital converter 102;

the analog-to-digital converter 102 is configured to convert the received field data that is in the form of an analog signal into field data that is in the form of a digital signal and then send the converted field data to the control processor 103;

the control processor 103 is configured to process the received field data that is in the form of a digital signal and then send the processed field data to the Profinet interface 104; and

the Profinet interface 104 is configured to send the received field data that is in the form of a digital signal to an external control end over the industrial Ethernet.

The above embodiments of the present invention provide a field data transmission apparatus, wherein an analog signal acquisition and conditioning module receives field data that is in the form of an analog signal and sent by an external sensor; an analog-to-digital converter converts the field data that is in the form of an analog signal into field data that is in the form of a digital signal; and after a control processor processes the field data that is in the form of a digital signal, a Profinet interface sends the processed field data that is in the form of a digital signal to an external control end over an industrial Ethernet. Since the Profinet interface can implement long-distance transmission of digital signals, the field data transmission apparatus can be arranged at one side close to the sensor. Thus, the sensor sending an analog signal to the field data transmission apparatus uses short-distance transmission, thereby avoiding interference and attenuation introduced by the long-distance transmission of analog signals, and thus improving the quality of data transmission.

In one embodiment of the present invention, the Profinet interface comprises a packaging processing unit and an Ethernet physical layer processing unit, wherein the

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packaging processing unit performs packaging processing on the received field data that is in the form of a digital signal, and sends the packaging processed field data that is in the form of a digital signal to the Ethernet physical layer processing unit; and the Ethernet physical layer processing unit sends the received field data that is in the form of a digital signal to an external control end over the industrial Ethernet. In the process of the Ethernet physical layer processing unit sending the field data that is in the form of a digital signal, the packaging processing unit controls the sending process of the Ethernet physical layer processing unit to reduce the delay of data communication, so that the Profinet interface can transmit data in a synchronous real-time communication (IRT) mode, thereby improving the transmission speed of the field data that is in the form of a digital signal, reducing communication jitter, and ensuring the real time performance and the precision of data transmission.

In one embodiment of the present invention, the packaging processing unit can be arranged in a flexible manner, that is to say, the packaging processing unit can be either independently arranged or can be integrated into an existing device, for example, the packaging processing unit can be either an independently arranged ASIC or can be an embedded real-time unit or FPGA integrated into the control processor, and the specific arrangement method can be flexibly selected according to practical service requirements, so that the applicability of the field data transmission apparatus is improved.

In one embodiment of the present invention, the field data transmission apparatus also comprises a power supply module, with one end of the power supply module being connected to the analog signal acquisition and conditioning module, the analog-to-digital converter, the control processor and the Profinet interface, and the other end thereof being connected to an industrial Ethernet; and the power supply module receives AC power or DC power transmitted by an external switch over the industrial Ethernet, and converts the received AC power or DC power into available DC power or AC power and then supplies same to the analog signal acquisition and conditioning module, the analog-to-digital converter, the control processor and the Profinet interface for use. Thus, by means of the power supply module, power can be supplied to the field data transmission apparatus over the industrial Ethernet, without needing to separately equip the field data transmission apparatus with a power supply, thereby facilitating the installation of the field data transmission apparatus on one hand, and being able to reduce the costs of the field data transmission apparatus on the other hand.

In one embodiment of the present invention, the field data transmission apparatus further comprises a configuration interface, with one end of the configuration interface being connected to the control processor and the other end thereof being connected to an external computer; the computer sends configuration information to the configuration interface, and

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the configuration interface receives the configuration information and then sends same to the control processor; and the control processor controls, according to the received configuration information, the process of converting the field data that is in the form of an analog signal into the field data that is in the form of a digital signal, which is executed by the analog-to-digital converter, and the configuration information is sent to the control processor by means of the configuration interface so as to convert the field data through different parameters, thereby improving the applicability of the field data transmission apparatus.

In one embodiment of the present invention, the field data transmission apparatus also comprises a data memory, wherein the data memory is connected to the control processor; while processing the field data that is in the form of a digital signal, the control processor sends the field data that is in the form of a digital signal before processing or the field data that is in the form of a digital signal after processing to the data memory, and the data memory stores the received field data that is in the form of a digital signal; and when receiving an access instruction from the external control end or computer, the control processor reads the field data that is in the form of a digital signal from the data memory and then sends same to the control end or computer. Thus, when a problem occurs in an industrial production field, the field data that is in the form of a digital signal stored in the data memory can be read, and by analyzing the read field data that is in the form of a digital signal, the reason why the problem occurred in the industrial production field is determined.

As shown in Fig. 2, one embodiment of the present invention provides a data transmission system, comprising: a sensor 201, a control end 203 and any one of the field data transmission apparatuses 202 provided in the embodiments above, the sensor 201 and the field data transmission apparatus 202 being both arranged on a data acquisition field, wherein

the sensor 201 is configured to acquire field data and send the field data that is in the form of an analog signal to the field data transmission apparatus 202; and

the control end 203 is configured to receive, over an industrial Ethernet, field data that is in the form of a digital signal and sent by the field data transmission apparatus 202 via a Profinet interface.

The embodiments of the present invention provide a data transmission system, wherein field data is acquired by a sensor; after the acquired field data is converted into field data that is in the form of an analog signal, the field data that is in the form of an analog signal is sent to a field data transmission apparatus; the field data transmission apparatus performs corresponding processing on the field data that is in the form of an analog signal and converts the processed field data into field data that is in the form of a digital signal; and the field data that is in the form of a digital signal is sent to a control end over an industrial Ethernet. Since

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the control end is connected to the Profinet interface in the field data transmission apparatus over the industrial Ethernet, and the Profinet interface is suitable for long-distance transmission, the field data transmission apparatus can be arranged at one side close to the sensor, thereby reducing the transmission distance of the field data that is in the form of an analog signal in the system, avoiding interference and attenuation introduced by the long-distance transmission of analog signals, and thus improving the quality of data transmission.

In one embodiment of the present invention, the control end can be a PLC or an industrial PC, so that the PLC or the industrial PC can be applied to industrial applications, e.g., applications having strict requirements for time and data precision, in combination with the application of the Profinet interface.

As shown in Fig. 3, one embodiment of the present invention provides a method for performing field data transmission using any one of the field data transmission apparatuses above, wherein the field data transmission apparatus is disposed on a data acquisition field in advance, and the method comprises:

Step 301: receiving, by using the analog signal acquisition and conditioning module, field data that is in the form of an analog signal and sent by an external sensor, and conditioning the field data that is in the form of an analog signal;

Step 302: converting, by using the analog-to-digital converter, the conditioned field data that is in the form of an analog signal into field data that is in the form of a digital signal;

Step 303: processing, by using the control processor, the field data that is in the form of a digital signal; and

Step 304: sending, by using the Profinet interface, the received field data that is in the form of a digital signal to an external control end over an industrial Ethernet.

In one embodiment of the present invention, when the field data transmission apparatus comprises a power supply module, the power supply module receives AC power or DC power transmitted over the industrial Ethernet, and converts the received AC power or DC power into available DC power or AC power and then supplies same to the field data transmission apparatus so as to provide electrical energy for the field data transmission apparatus without needing to separately equip the field data transmission apparatus with a power supply, thereby facilitating the arrangement of the field data transmission apparatus.

In order to more clearly embody the implementation of the data transmission system in the embodiments of the present invention, by taking the data transmission system comprising a computer and the field data transmission apparatus comprising a configuration interface and a data memory as an example, the implementation will be further illustrated below in conjunction with Fig. 4.

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As shown in Fig. 4, one embodiment of the present invention provides a field data transmission system, comprising: a sensor 401, a field data transmission apparatus 402, a control end 403 and a computer 404;

wherein the sensor 401 is connected to an analog signal acquisition and conditioning module 4021 in the field data transmission apparatus 402, the control end 403 is connected to an Ethernet physical layer processing unit 40242 in the field data transmission apparatus 402, and the computer 404 is connected to a configuration interface 4026 in the field data transmission apparatus 402;

the sensor 401 acquires field data in an industrial production field, converts the acquired field data into field data that is in the form of an analog signal and sends the converted field data to the analog signal acquisition and conditioning module 4021; the field data transmission apparatus 402 performs corresponding conversion and processing on the received field data that is in the form of an analog signal, and sends the converted field data that is in the form of a digital signal to the control end 403 via the Ethernet physical layer processing unit 40242; and

the computer 404 sends configuration information to a control processor 4023 via the configuration interface 4026, and controls the analog-to-digital converter 4022 to convert the field data.

In order to more clearly embody the process of the data transmission method in the embodiments of the present invention, the process will be described in detail below in conjunction with the data transmission system shown in Fig. 4.

With reference to Figs. 4 and 5, the process comprises:

Step 501: The control processor receives configuration information via the configuration interface in the field data transmission apparatus.

In one embodiment of the present invention, as shown in Fig. 4, the computer 404 is connected to the configuration interface 4026, the computer 404 sends the configuration information to the control processor 4023 via the configuration interface 4026, and the configuration information can configure subsequent sampling rates and sampling digits, for example.

Step 502: The sensor acquires field data in an industrial production field, and sends the field data in the form of an analog signal to the analog signal acquisition and conditioning module.

In one embodiment of the present invention, as shown in Fig. 4, the sensor 401 acquires field data that is in the form of a physical signal from the operation of an industrial production field device, converts the field data that is in the form of the physical signal into field data that is in the form of an electrical analog signal via a relevant conversion module,

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and sends the converted field data that is in the form of an analog signal to the analog signal acquisition and conditioning module 4021. For example, the sensor acquires a current value on a power transport line, converts the acquired current value into current data that is in the form of an analog signal reflecting the size of the current value, and sends the converted
5 current data that is in the form of an analog signal to the analog signal acquisition and conditioning module.

Step 503: The analog signal acquisition and conditioning module conditions the field data that is in the form of an analog signal, and sends the conditioned field data that is in the form of an analog signal to the analog-to-digital converter.

10 In one embodiment of the present invention, the analog signal acquisition and conditioning module 4021 may comprise conditioning modules, such as a filtering unit, an amplification unit, an over-current protection unit and an over-voltage protection unit, wherein the filtering unit performs filtering processing on the field data that is in the form of an analog signal, the amplification unit performs signal amplification processing on the field data that is
15 in the form of an analog signal, the over-current protection unit is configured to prevent the current in a line transmitting the field data from exceeding a critical value, and the over-voltage protection unit is configured to prevent the voltage in a line transmitting the field data from exceeding a critical value. By means of processing performed by the filtering unit, the amplification unit, the over-current protection unit, the over-voltage protection unit, etc.,
20 the field data that is in the form of an analog signal is conditioned into field data that is in the form of an analog signal that can be used by the analog-to-digital converter. For example, the filtering unit in the analog signal acquisition and conditioning module performs filtering processing on the current data that is in the form of an analog signal so as to filter out disordered and interference waveforms; the amplification unit amplifies the waveforms of the
25 field data that is in the form of an analog signal, so that the field data that is in the form of an analog signal can be recognized by the analog-to-digital converter; and the over-voltage protection unit and the over-current protection unit prevent the voltage and the current in a line transmitting the current data from exceeding a safe voltage and current. By processing of
30 the filtering unit, the amplification unit, the over-current protection unit and the over-voltage protection unit, the current data that is in the form of an analog signal is conditioned into current data that is in the form of an analog signal that can be used by the analog-to-digital converter.

Step 504: The analog-to-digital converter converts the field data that is in the form of an analog signal into field data that is in the form of a digital signal, and sends the converted field
35 data that is in the form of a digital signal to the control processor.

In one embodiment of the present invention, as shown in Fig. 4, after receiving the field

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data that is in the form of an analog signal sent by the analog signal acquisition and conditioning module 4021, the analog-to-digital converter 4022 receives a control instruction, which is sent by the control processor 4023 according to the configuration information, converts, according to the received control instruction, the field data that is in the form of an analog signal into field data that is in the form of a digital signal at a corresponding sampling rate and a sampling digit, and sends the converted field data that is in the form of a digital signal to the control processor. For example, after receiving the current data that is in the form of an analog signal sent by the analog signal acquisition and conditioning module, the analog-to-digital converter receives a control instruction sent by the control processor, performs conversion on the current data that is in the form of an analog signal at a 64 point per minute sampling rate and a 16-bit sampling digit according to the sampling rate and sampling digit specified in the control instruction so as to convert same into current data that is in the form of a digital signal, and sends the converted current data that is in the form of a digital signal to the control processor.

Step 505: The control processor processes the field data that is in the form of a digital signal, and sends the processed field data that is in the form of a digital signal to the Profinet interface and stores same in the data memory, respectively.

In one embodiment of the present invention, the control processor 4023 can be a microprocessor (MPU), an FPGA, a digital signal processor (DSP) or a combination of an FPGA and a micro control unit (MCU); after receiving the field data that is in the form of a digital signal sent by the analog-to-digital converter 4022, the control processor 4023 respectively performs digital filtering processing, signal format conversion processing and signal compression processing on the field data that is in the form of a digital signal, and further optimizes the field data that is in the form of a digital signal; and after the processing finishes, the control processor 4023 stores the processed field data that is in the form of a digital signal in the data memory 4025 on one hand, and sends the processed field data that is in the form of a digital signal to the Profinet interface 4024 on the other hand. For example, after receiving the current data that is in the form of a digital signal sent by the analog-to-digital converter, the control processor performs digital filtering processing, signal format conversion processing and signal compression processing on the current data that is in the form of the electrical digital signal, and stores, after completion of processing, the processed current data that is in the form of a digital signal in the data memory on one hand, and sends the processed current data that is in the form of a digital signal to the Profinet interface on the other hand, wherein the data memory can be a Flash memory or an SD card.

Step 506: The Profinet interface sends the field data that is in the form of a digital signal to a control end.

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In one embodiment of the present invention, as shown in Fig. 4, the Profinet interface comprises an ASIC 40241 and an Ethernet physical layer processing unit 40242, wherein after receiving the field data that is in the form of a digital signal sent by the control processor 4023, the ASIC 40241 performs packaging processing on the field data that is in the form of a digital signal, and sends the processed field data to the Ethernet physical layer processing unit 40242 after packaging processing; and the Ethernet physical layer processing unit 40242 is connected to the control end 403 over the industrial Ethernet, and the Ethernet physical layer processing unit 40242 sends the packaged field data that is in the form of a digital signal to the control end 403 over the industrial Ethernet. For example, after receiving current data that is in the form of a digital signal sent by the control processor, the ASIC packages the current data that is in the form of a digital signal into a standard block and then sends the standard block to the Ethernet physical layer processing unit, and the Ethernet physical layer processing unit sends the received packaged current data that is in the form of a digital signal to the control end over the industrial Ethernet, wherein the Ethernet physical layer processing unit can be a physical (PHY) layer chip.

Step 507: The control end takes a corresponding control measure according to the received field data that is in the form of a digital signal.

In one embodiment of the present invention, as shown in Fig. 4, after receiving the field data that is in the form of a digital signal sent by the Ethernet physical layer processing unit 40242, the control end 403 determines, according to the field data that is in the form of a digital signal, whether an abnormality has occurred in the industrial production field, and makes corresponding control measures when abnormalities occur. For example, after receiving the current data that is in the form of a digital signal sent by the Ethernet physical layer processing unit, the control end determines, according to the current data that is in the form of a digital signal, whether the current on the power transport line exceeds a pre-set safety value, and if so, sends a corresponding control instruction to cut off the power transport line so as to prevent an accident caused by over-current on the current transport line.

It should be noted that in one embodiment of the present invention, the field data transmission apparatus 402 further comprises a power supply module, with one end of the power supply module being respectively connected to the analog signal acquisition and conditioning module 4021, the analog-to-digital converter 4022, the control processor 4023, the Profinet interface 4024, the data memory 4025 and the configuration interface 4026, and the other end thereof being connected to an industrial Ethernet; and a switch transmits AC power or DC power to the power supply module over the industrial Ethernet, and the power supply module performs processing such as filtering and voltage transformation on the received AC power or the DC power so as to convert same into AC power or DC power that

can be used by various modules in the field data transmission apparatus 402 for the working of the various modules, without needing to separately equip the field data transmission apparatus 402 with a power supply, wherein the industrial Ethernet can be an industrial Ethernet supporting power supply to the Profinet interface, and the corresponding switch needs to support the corresponding power supply mode.

It should be further noted that when an abnormality occurs in an industrial production field, the field data that is in the form of a digital signal stored in the data memory 4025 can be read via the computer 404, and, by analyzing the read field data that is in the form of a digital signal, the reason why the abnormality occurs in the industrial production field can be determined so as to further perform responsibility investigation.

According to the above-mentioned solutions, the field data transmission apparatus, method and system provided in various embodiments of the present invention at least have the beneficial effects as follows:

1. Field data that is in the form of an analog signal and sent by an external sensor is received by an analog signal acquisition and conditioning module, an analog-to-digital converter converts the field data that is in the form of an analog signal into field data that is in the form of a digital signal, and after a control processor processes the field data that is in the form of a digital signal, a Profinet interface sends the processed field data that is in the form of a digital signal to an external control end over an industrial Ethernet; and since the Profinet interface can implement long-distance transmission of digital signals, the field data transmission apparatus can be arranged at one side close to the sensor, and thus the sensor sending an analog signal to the field data transmission apparatus uses short-distance transmission, thereby avoiding interference and attenuation introduced by the long-distance transmission of analog signals, and thus improving the quality of data transmission.

2. When the field data transmission apparatus comprises a power supply module, with one end of the power supply module being respectively connected to other modules in the field data transmission apparatus and the other end thereof being connected to a switch over an industrial Ethernet, the switch transmits electric energy to the power supply module over the industrial Ethernet; after performing corresponding conversion on the received electric energy, the power supply module supplies same to various modules in the field data transmission apparatus for use; by means of the power supply module, power can be supplied to the field data transmission apparatus over the industrial Ethernet, without needing to separately equip the field data transmission apparatus with a power supply, which can reduce the costs of the field data transmission apparatus and facilitate the arrangement of the field data transmission apparatus.

3. When the field data transmission apparatus comprises a data memory, the control

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processor stores, after receiving the field data that is in the form of a digital signal, the field data that is in the form of a digital signal in the data memory, and thus when an abnormality occurs in the industrial production field, by reading the field data stored in the data memory via the computer or the control end, the abnormality reason can be analyzed so as to provide
5 a basis for subsequent improvement work and responsibility investigation.

4. The Profinet interface comprises a packaging processing unit, wherein the packaging processing unit controls the sending process of the Ethernet physical layer processing unit except for performing packaging processing on the field data that is in the form of a digital signal, and reduces the delay of performing data communication with the control end, so that
10 the field data transmission apparatus can perform data transmission in a synchronous real-time communication (IRT) mode, and the precision of the field data transmission is improved.

It should be noted that in this application the terminology "include", "comprise" or any other variant is intended to cover non-exclusive inclusion, so that a process, a method, an object or a device that includes a series of elements not only includes those elements, but
15 also includes other elements that are not explicitly listed, or includes inherent elements of the process, method, object or device. An element preceded by "comprising a..." does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that includes the element.

Those skilled in the art may understand: all or a part of the steps for implementing the above-mentioned method embodiments can be completed by a program instructing related hardware. The foregoing program can be stored in a computer-readable storage medium. When the program is being executed, the steps of the comprised method embodiments above are executed; in addition, the foregoing storage medium comprises: various media
20 which can store program codes, such as a ROM, a RAM, a magnetic disk, or an optical disk.

Finally, it should be noted that what is described above represents merely preferred embodiments of the present invention, and is merely for illustration of the technical solutions of the present invention, but is not for limiting the protection scope of the present invention. All the modifications, equivalent replacements, and improvements made within the spirit and
30 principle of the present invention are encompassed within the protection scope of the present invention.

CLAIMS

1. A field data transmission apparatus, comprising:

an analog signal acquisition and conditioning module, an analog-to-digital converter, a
5 control processor and a Profinet interface, wherein the Profinet interface accesses an industrial Ethernet;

the analog signal acquisition and conditioning module is configured to receive field data
that is in the form of an analog signal and sent by an external sensor, and, after conditioning
the field data that is in the form of an analog signal, send the conditioned field data to the
10 analog-to-digital converter;

the analog-to-digital converter is configured to convert the received field data that is in
the form of an analog signal into field data that is in the form of a digital signal and then send
the converted field data to the control processor;

the control processor is configured to process the received field data that is in the form
15 of a digital signal and then send the processed field data to the Profinet interface; and

the Profinet interface is configured to send the received field data that is in the form of a
digital signal to an external control end over the industrial Ethernet.

2. The apparatus as claimed in claim 1, wherein

20 the Profinet interface comprises: a packaging processing unit and an Ethernet physical layer processing unit;

wherein the packaging processing unit is configured to perform packaging processing
on the field data that is in the form of a digital signal and sent by the control processor, send
the packaged field data that is in the form of a digital signal to the Ethernet physical layer
25 processing unit, and control the sending process of the Ethernet physical layer processing
unit; and

the Ethernet physical layer processing unit is configured to send the packaged field data
that is in the form of a digital signal to the control end over the industrial Ethernet.

3. The apparatus as claimed in claim 2, wherein

the packaging processing unit comprises: an independently arranged
application-specific integrated circuit (ASIC);

or,

the packaging processing unit comprises: an embedded real-time unit or a field
35 programmable gate array (FPGA) integrated inside the control processor.

4. The apparatus as claimed in claim 1, further comprising: a power supply module;
wherein the power supply module is connected to the industrial Ethernet and configured
to receive AC power or DC power transmitted over the industrial Ethernet, and convert the
received AC power or DC power into available DC power or AC power for power supply.

5. The apparatus as claimed in claim 1, further comprising: a configuration interface;
wherein the configuration interface is connected to the control processor and configured
to receive configuration information sent by an external computer, and send the configuration
information to the control processor; and

the control processor is further configured to control, according to the received
configuration information, the analog-to-digital converter to perform the conversion.

6. The apparatus as claimed in any one of claims 1-5, further comprising: data
memory;

wherein the control processor is further configured to store the field data that is in the
form of a digital signal in the data memory, and send the field data that is in the form of a
digital signal in the data memory to the control end or computer when receiving an access
instruction from the control end or computer; and

the data memory is configured to store the field data that is in the form of a digital signal.

7. A method for performing field data transmission using the field data transmission
apparatus of any one of claims 1-6, wherein the field data transmission apparatus is disposed
on a data acquisition field in advance, and the method comprises:

receiving, by using the analog signal acquisition and conditioning module, field data that
is in the form of an analog signal and sent by an external sensor, and conditioning the field
data that is in the form of an analog signal;

converting, by using the analog-to-digital converter, the conditioned field data that is in
the form of an analog signal into field data that is in the form of a digital signal;

processing, by using the control processor, the field data that is in the form of a digital
signal; and

sending, by using the Profinet interface, the received field data that is in the form of a
digital signal to an external control end over an industrial Ethernet.

8. The method as claimed in claim 7, wherein, when the field data transmission
apparatus comprises a power supply module, the method further comprises:

receiving, by using the power supply module, AC power or DC power transmitted over

the industrial Ethernet, and converting the received AC power or DC power into available DC power or AC power for power supply.

9. A field data transmission system, comprising:

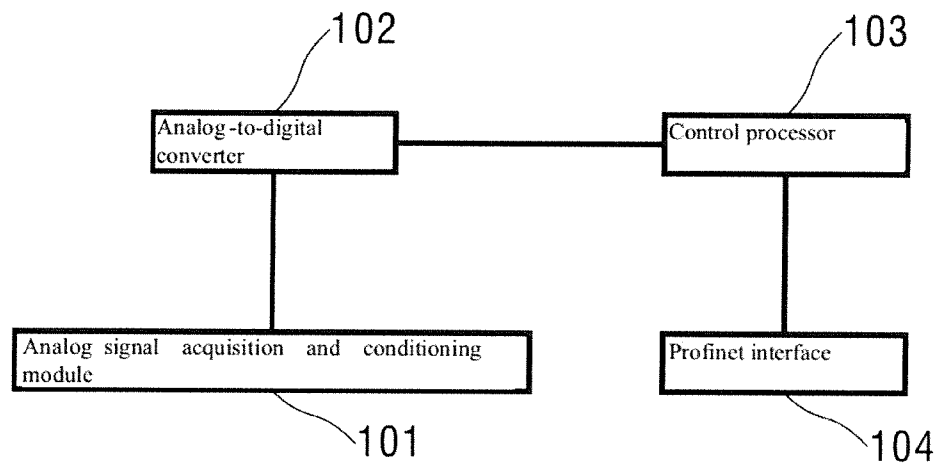
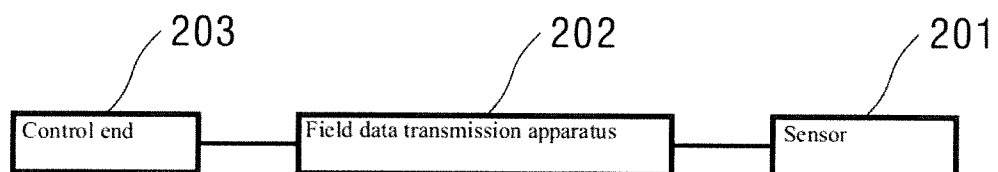
5 a sensor, a control end and a field data transmission apparatus of any one of claims 1-6, the sensor and the field data transmission apparatus being both arranged in a data acquisition field; wherein

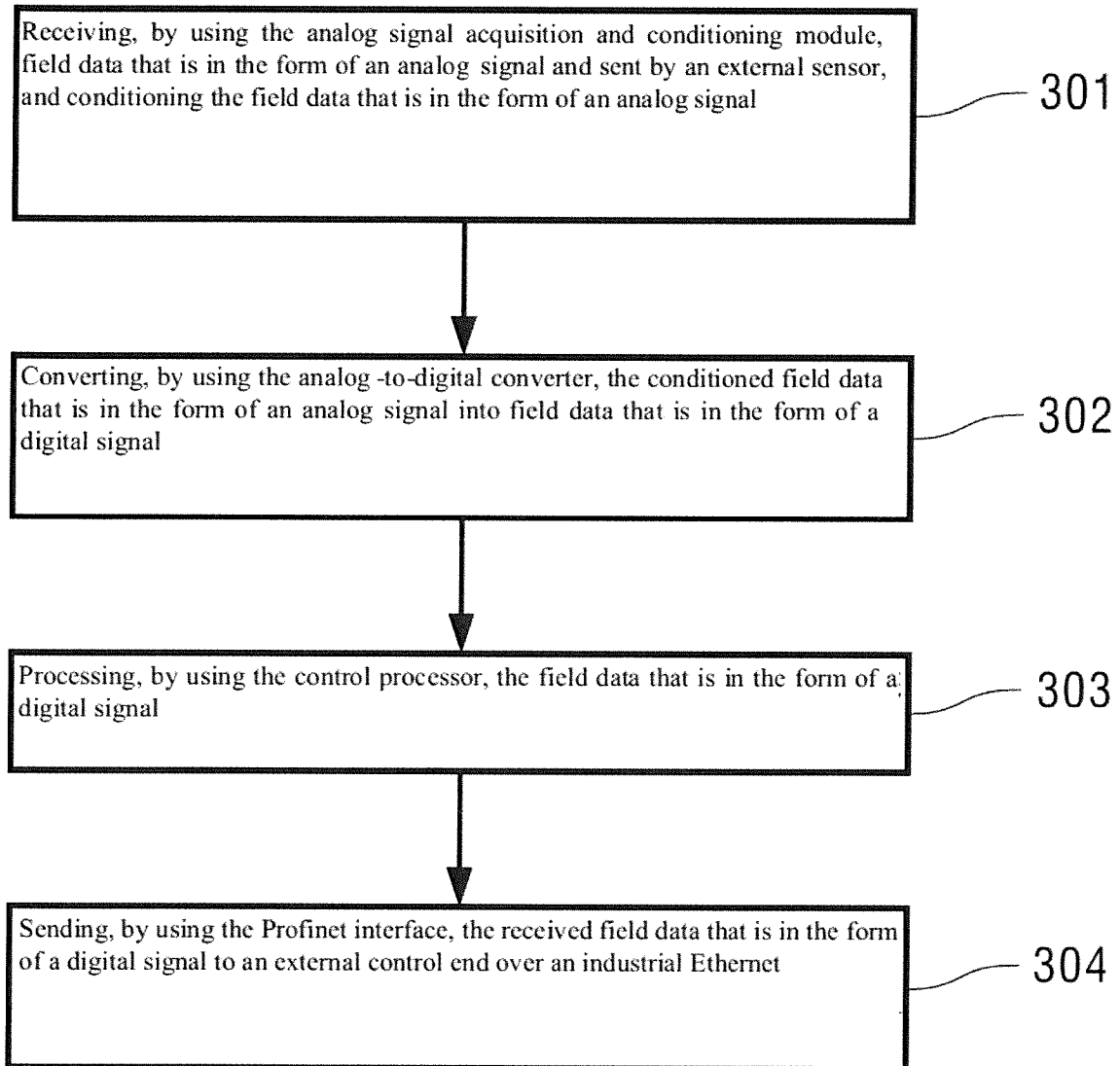
the sensor is configured to acquire field data and send the field data that is in the form of an analog signal to the field data transmission apparatus; and

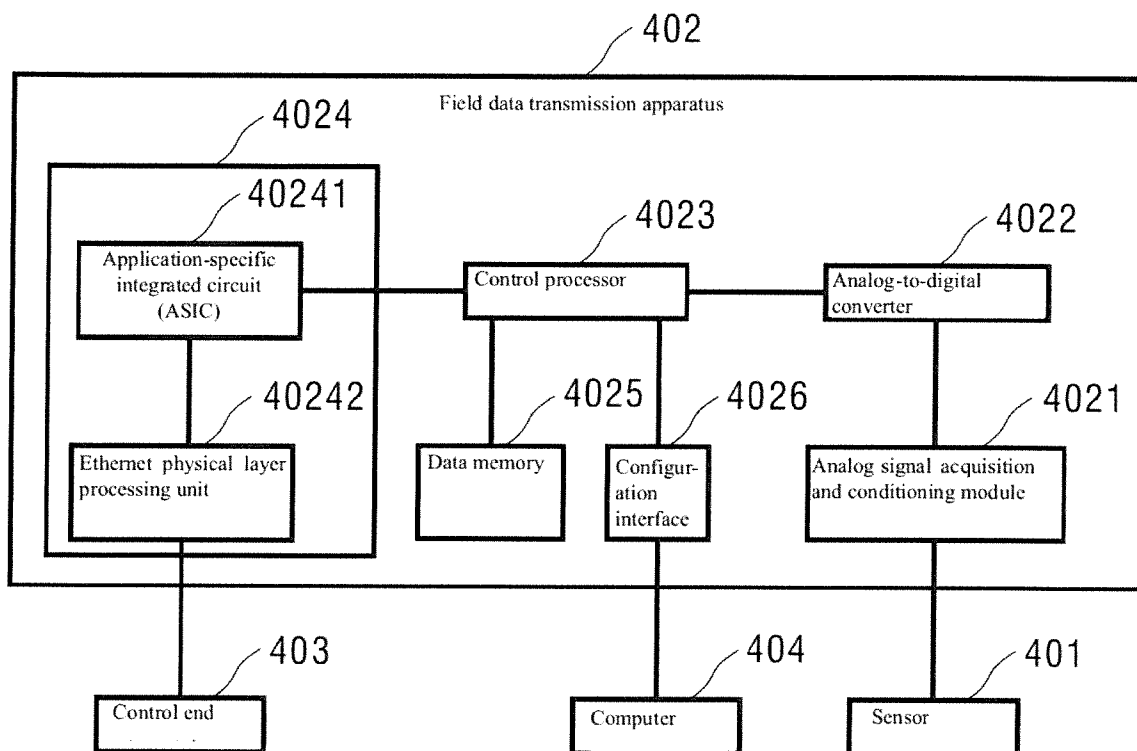
10 the control end is configured to receive, over an industrial Ethernet, field data that is in the form of a digital signal and sent by the field data transmission apparatus via a Profinet interface.

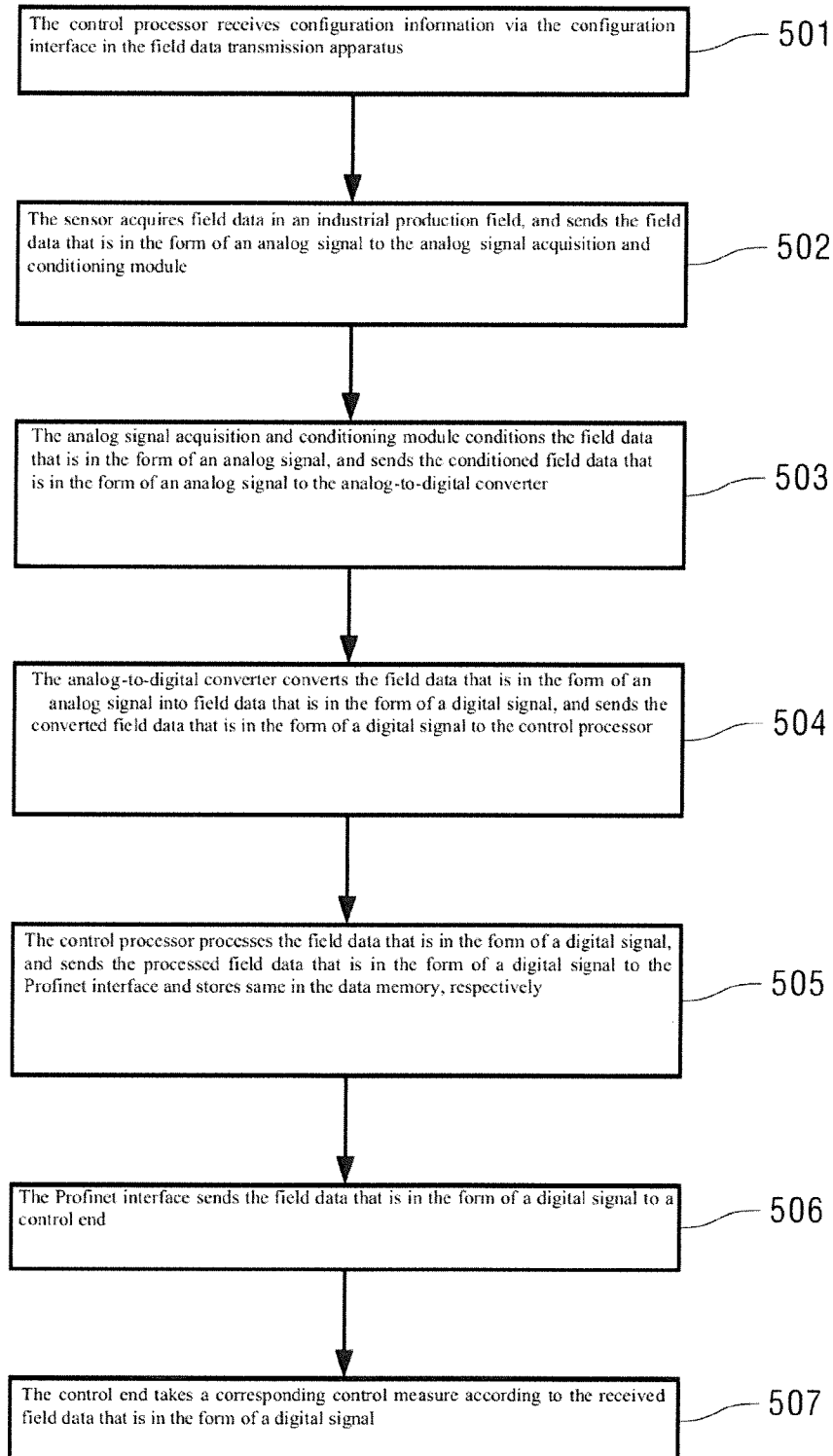
10. The data transmission system as claimed in claim 9, wherein

15 the control end comprises: a programmable logic controller (PLC) or an industrial PC.

*Fig. 1**Fig. 2*

*Fig. 3*

*Fig. 4*

*Fig. 5*

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/050100A. CLASSIFICATION OF SUBJECT MATTER
INV. G05B19/042 G05B19/418
ADD.

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)
G05B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FLAMMINI A ET AL: "Sensor networks for industrial applications", ADVANCES IN SENSORS AND INTERFACE, 2007. IWASI 2007. 2ND INTERNATIONAL WORKSHOP ON, IEEE, PI, 26 June 2007 (2007-06-26), pages 1-15, XP031225139, ISBN: 978-1-4244-1244-0 the whole document ----- -/--	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" 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

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Date of the actual completion of the international search

28 February 2017

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/050100

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CAI LIMIN: "Design and research of a kind of smart sensor", COMPUTER SCIENCE&EDUCATION (ICCSE), 2012 7TH INTERNATIONAL CONFERENCE ON, IEEE, 14 July 2012 (2012-07-14), pages 1208-1211, XP032232788, DOI: 10.1109/ICCSE.2012.6295281 ISBN: 978-1-4673-0241-8 the whole document	1-10
X	----- JAEHOON OH ET AL: "The Development of Bay Control Unit with flexible IO module", ADVANCED POWER SYSTEM AUTOMATION AND PROTECTION (APAP), 2011 INTERNATIONAL CONFERENCE ON, IEEE, 16 October 2011 (2011-10-16), pages 1110-1114, XP032162620, DOI: 10.1109/APAP.2011.6180972 ISBN: 978-1-4244-9622-8 the whole document -----	1-10