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(54) **MULTI-DATA-RATE OPTICAL TRANSCEIVER**

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(58) **Field of Classification Search** 398/135, 398/138, 139, 130, 128, 136, 137
See application file for complete search history.

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(57) **ABSTRACT**

An optical transceiver module includes an optical-to-electrical converter configured to convert a first optical signal to a first electric signal, a first amplifier configured to amplify the first electric signal, a bandwidth controller coupled to the first amplifier, configured to control the frequency response characteristics of the amplification of the first amplifier to produce a first amplified electric signal, a driver circuit configured to receive a second electric signal and to produce a second amplified electric signal in response to the second electric signal and an optical feedback signal, an electrical-to-optical converter coupled to the micro-controller and configured to convert the second amplified electrical signal to a second optical signal, and a photo diode configured to detect the second optical signal and to produce the optical feedback signal to be received by the driver circuit.

41 Claims, 5 Drawing Sheets

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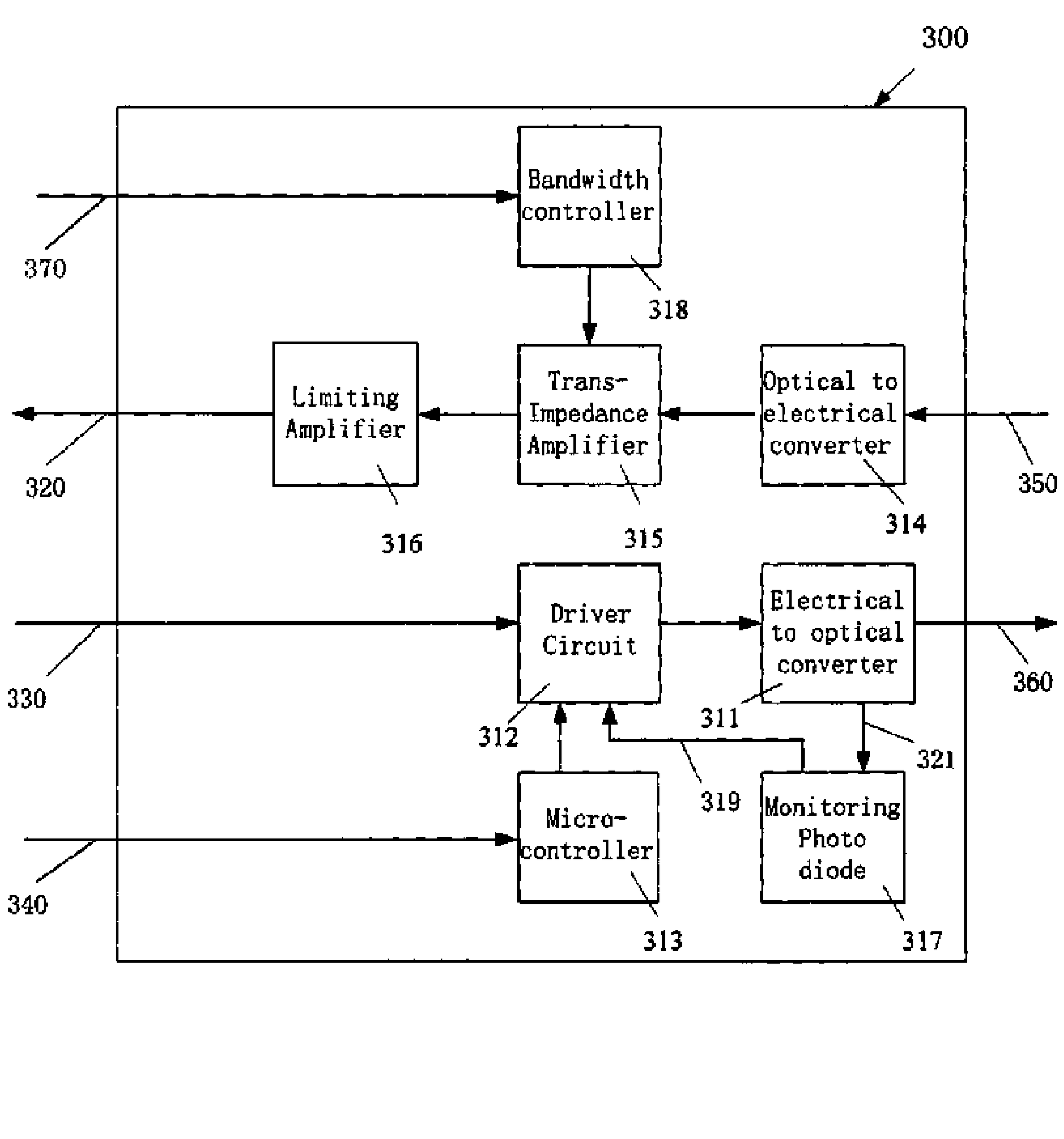

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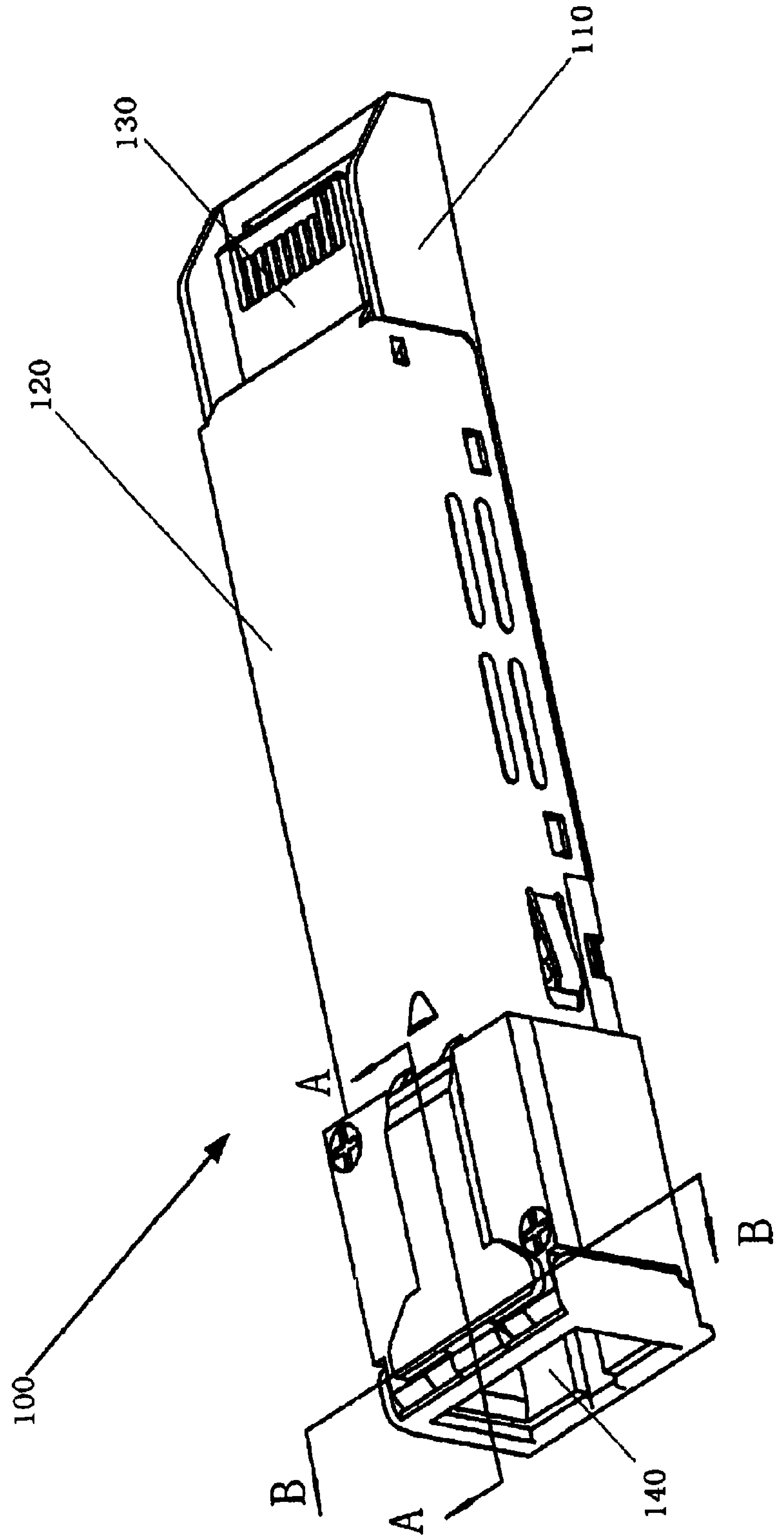

FIG 1

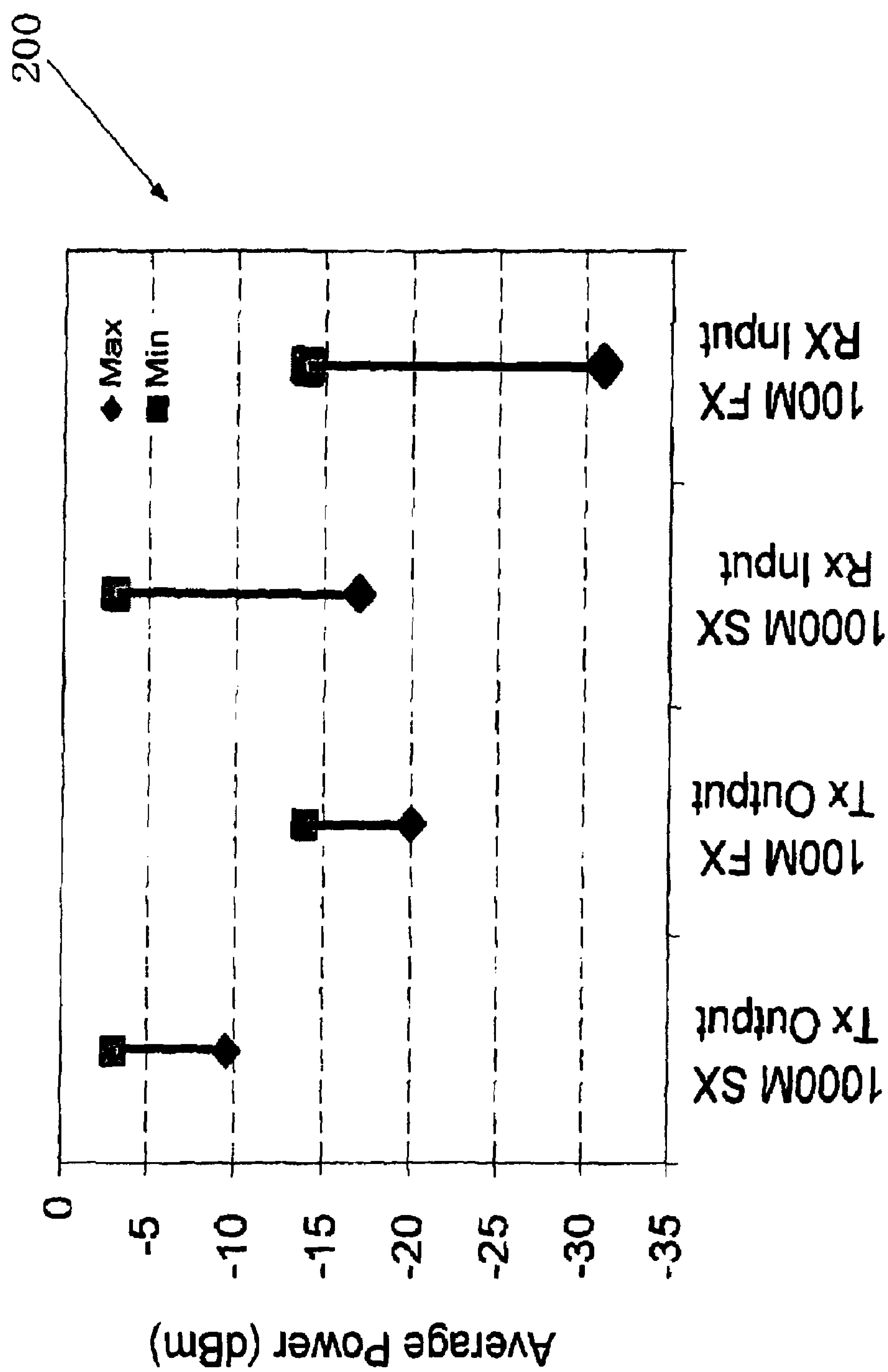
200
Max
Min
1000M SX Tx Output
100M FX Tx Output
1000M SX Rx Input
100M FX RX Input
0
-5
-10
-15
-20
-25
-30
-35
Average Power (dBm)

FIG 2

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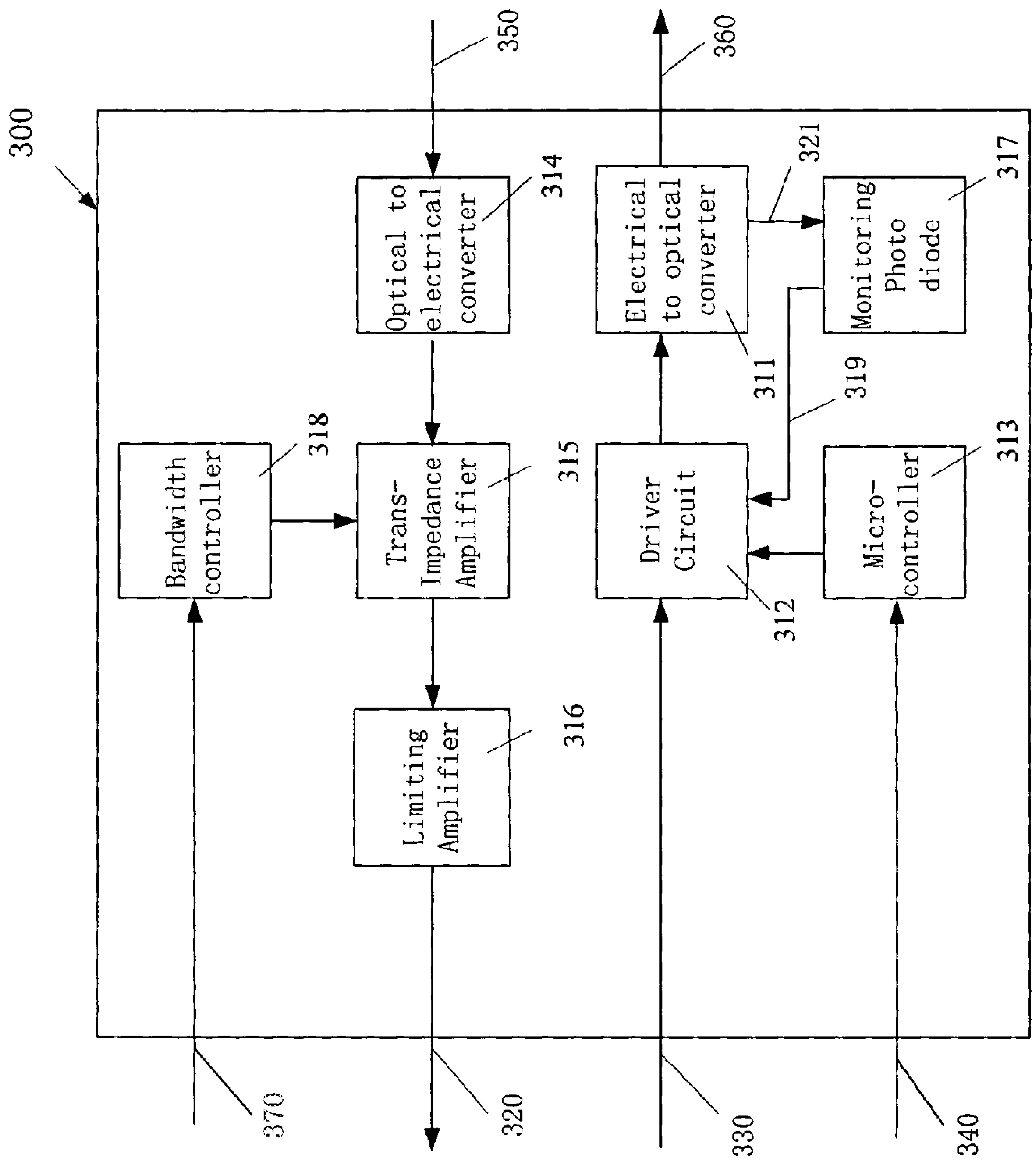

Fig 3

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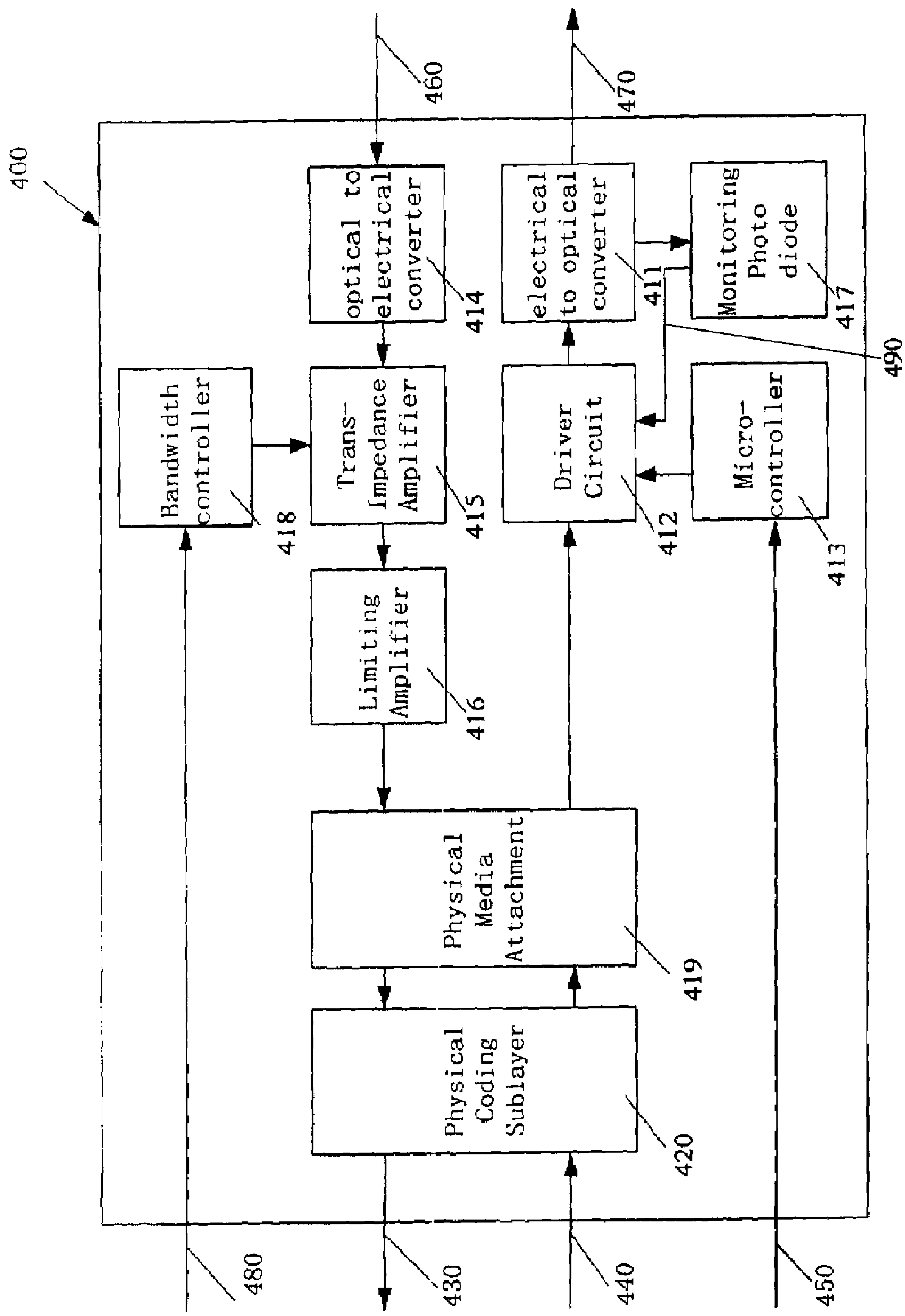

Fig 4

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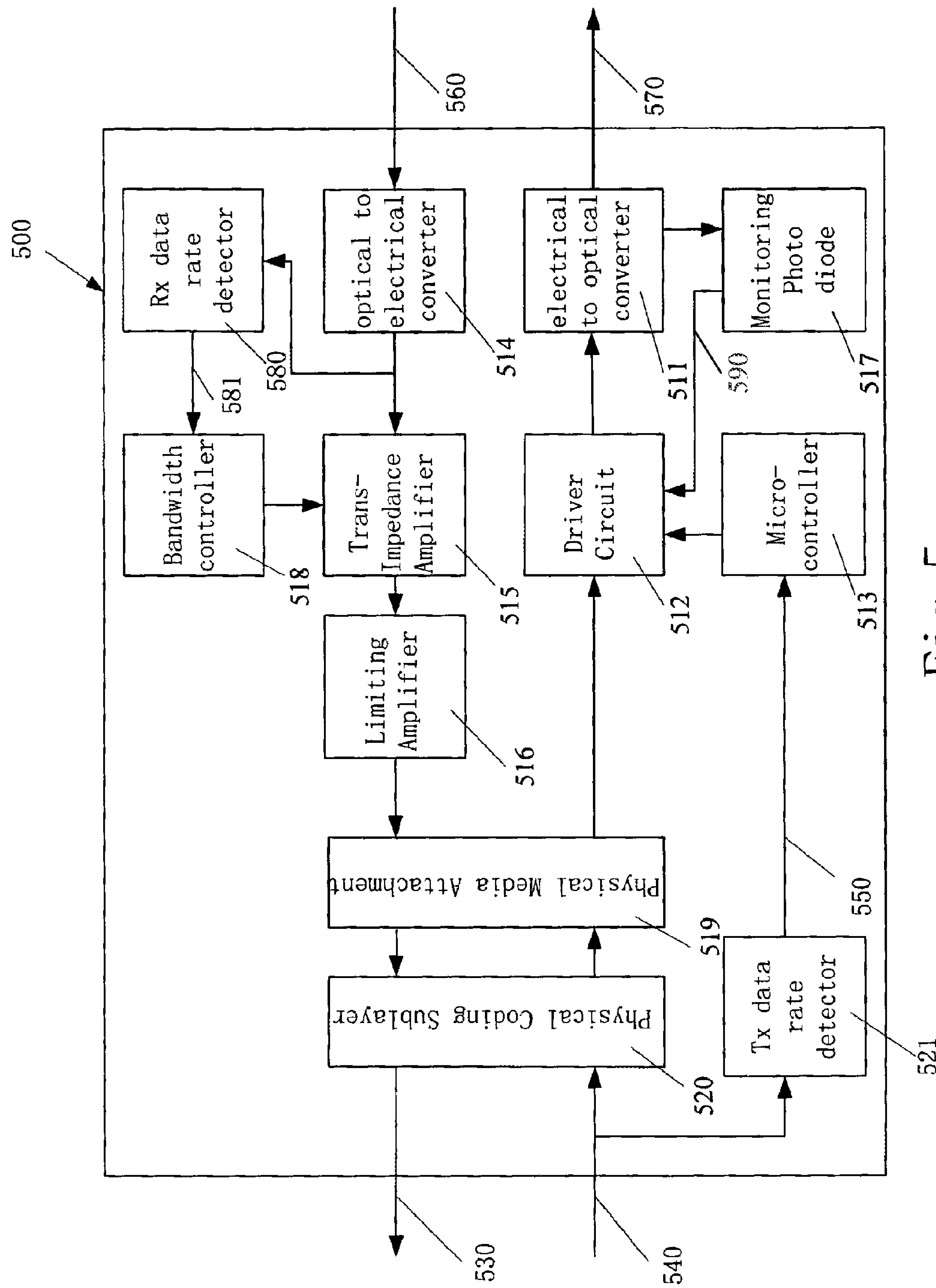

Fig 5

MULTI-DATA-RATE OPTICAL TRANSCEIVER

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

CROSS-REFERENCES TO RELATED INVENTIONS

The present application is a continuation of U.S. patent application Ser. No. 11/257,627, filed on Oct. 25, 2005, now U.S. Pat. No. 7,200,336. The present invention is related to commonly assigned U.S. patent application Ser. No. 10/741,805, filed on Dec. 19, 2003, titled "Bi-directional optical transceiver module having automatic-restoring unlocking mechanism", commonly assigned U.S. patent application Ser. No. 10/815,326, filed on Apr. 01, 2004, titled "Small form factor pluggable optical transceiver module having automatic-restoring unlocking mechanism and mechanism for locating optical transceiver components", commonly assigned U.S. patent application Ser. No. 10/850,216, filed on May 20, 2004, titled "Optical Transceiver module having improved printed circuit board", commonly assigned U.S. patent application Ser. No. 10/893,803, filed on Jul. 19, 2004, titled "Single fiber optical transceiver module", and commonly assigned Chinese Patent Application No. 200420034040.X filed on Jun. 15, 2004, titled "An APD Bias Voltage Test Equipment". The disclosures of these related applications are incorporated herein by reference.

TECHNICAL FIELD

This disclosure relates to electro-optical devices, specifically, an optical transceiver.

BACKGROUND

An optical transceiver is a device that can **[**covert**]** *convert* optical signals into electrical signals and convert electrical signals into optical signals. Various standards in the telecommunication and data communication industries specify the rates of data transmissions. For example, the original Ethernet standard has a data rate of 10 Mega bit per second (Mbps). Fast Ethernet's data rate is 100 Mbps, and Gigabit Ethernet transmits and receives data at a rate of 1000 Mbps. Compliance with the standards is important for **[**inter-operatability**]** *interoperability* between different vendors for a wide range of commercial applications. Different industry standards such as the IEEE standard include requirements on the optical interface of an optical transceiver. Particularly, the average output power of an optical transceiver for the 100 Mbps Ethernet is between −20 and −15 dBm, while that for the 1000 Mbps Ethernet is between −10 and 4 dBm. Similarly, the required average input power for 100 Mbps Ethernet is from −30 dBm to −15 dBm while that for 1000 Mbps Ethernet is from −17 dBm to −3 dBm. The currently commercially available optical transceivers interface include only fixed data rate under a fixed optical specification. There is therefore a need for networks operating at different data rates to properly communicate with each other. There is also a need for networks to upgrade to higher data rates without excessive costs and time.

SUMMARY

In one aspect, the present invention relates to an optical transceiver module, comprising an optical-to-electrical con-

verter configured to convert a first optical signal to a first electric signal; a first amplifier configured to amplify the first electric signal; a bandwidth controller coupled to the first amplifier, configured to control the frequency response characteristics of the amplification of the first amplifier to produce a first amplified electric signal; a driver circuit configured to receive a second electric signal and to produce a second amplified electric signal in response to the second electric signal and an optical feedback signal; an electrical-to-optical converter coupled to the micro-controller and configured to convert the second amplified electrical signal to a second optical signal; and a photo diode configured to detect the second optical signal and to produce the optical feedback signal to be received by the driver circuit.

In another aspect, the present invention relates to an optical transceiver module, comprising an optical-to-electrical converter configured to convert a first optical signal to a first electric signal; a first amplifier configured to amplify the first electric signal; a bandwidth controller coupled to the first amplifier, configured to control the frequency response characteristics of the amplification of the first amplifier to produce an first amplified electric signal; a driver circuit configured to receive a second electric signal and to produce an amplified electric signal in response to the second electric signal and a optical feedback signal; an electrical-to-optical converter coupled to the micro-controller and configured to convert the amplified electrical signal to a second optical signal; an optical data-rate detector configured to detect the second optical signal and to produce the optical feedback signal to be received by the driver circuit; an optical interface configured to receive the first optical signal and output the second optical signal; and an electrical interface configured to receive the second electrical signal and output the first amplified electrical signal.

In yet another aspect, the present invention relates to an optical transceiver module, comprising an optical-to-electrical converter configured to convert a first optical signal to a first electric signal; a first amplifier configured to amplify the first electric signal; a bandwidth controller coupled to the first amplifier, configured to control the frequency response characteristics of the amplification of the first amplifier to produce **[**an**]** *a* first amplified electric signal; a driver circuit configured to receive a second electric signal and to produce an amplified electric signal in response to the second electric signal and **[**a**]** *an* optical feedback signal; an electrical-to-optical converter coupled to the micro-controller and configured to convert the amplified electrical signal to a second optical signal; an optical data-rate detector configured to detect the second optical signal and to produce the optical feedback signal to be received by the driver circuit; an optical interface configured to receive the first optical signal and output the second optical signal; and an electrical interface configured to receive the second electrical signal and output the first amplified electrical signal.

Embodiments may include one or more of the following advantages. The disclosed system provides a flexible multi-rate optical transceiver that enables a computer network to operate at different data rates.

Another advantage of the disclosed system that it allows networks or computer devices operating at different data rates to communicate with each other.

Yet another advantage of the disclosed system that it provides convenient means for upgrading a network or computer system from one data rate to a different data rate. The manual unplugging and plugging of optical transceivers on a network are eliminated during a data rate upgrade.

Still another advantage of the disclosed system that the multi-rate optical transceiver is more cost efficient by providing the capability of communicating at multiple data rates in one optical transceiver.

Another advantage of the disclosed system that it provides software control of an optical interface to allow data transmission at different data rates [and], compatible with communication standards at the different data rates.

DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view of an exemplified optical transceiver module in compatible with the present invention.

FIG. **2** is a chart for average power input and output for 100 Mbps and 1000 Mbps Ethernet in accordance with the present invention.

FIG. **3** is a block diagram for a multi-rate optical transceiver in accordance with an embodiment of the present invention.

FIG. **4** is a block diagram for a multi-rate optical transceiver with an electrical Media Independent Interface in accordance with another embodiment of the present invention.

FIG. **5** is a block diagram for a multi-rate optical transceiver with automatic data rate detection in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION

Reference will now be made in detail to the preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be obvious to one of conventional skill in the art that the present invention may be practiced without these specific details. In other instances, well known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the present invention.

FIG. **1** shows an optical transceiver **100** that can receive optical signals from an optical fiber and [coverts] *convert* the received optical signals into electrical signals. The optical transceiver **100** can also convert electrical signals into optical signals and [transmits] *transmit* the converted optical signals to an optical fiber. The optical transceiver **100** [include] *includes* an electrical to optical converter (for transmit purposes), and an optical-to-electrical converter (for receive purposes), a driver providing proper bias voltage and modulation for transmission *of* the output optical signals, and a limiting amplifier providing proper signal amplification for the optical-to-electrical converter.

It is desirable for an optical transceiver to be in compliance with industry standards. The different industry standards have [define] *defined* requirements on the optical interface and the electric interface of an optical transceiver. In particular, different industry standards require different input and output powers to and from an optical transceiver. FIG. **2** shows an example of the average input and output power requirements for 100 Mbps and 1000 Mbps Ethernets.

A conventional optical transceiver is built to transmit and receive data at a fixed data rate. An optical transceiver for 100 Mbps Ethernet cannot be used on a 1000 Mbps Ethernet network. However, it is very common that a server and its clients work at different data rates (a server working at 1000 Mbps and some of its clients working at 100 Mbps while its other clients working at 1000 Mbps for example). In this situation, the server needs to be connected with a plurality of optical transceivers that each operates at a different data rate. Furthermore, when a communication device needs to be upgraded from one data rate (e.g. 100 Mbps) to another data rate (e.g. 1000 Mbps), all the old optical transceivers have to be replaced by new optical transceivers capable of transmitting data at the new data rate. The upgrade can thus be costly and time consuming.

For an optical transceiver to operate on multiple data rates, it is desirable to be able to transmit and receive data at multiple data rates at both its electrical interface and its optical interface. The industry standard interfaces for the electrical interface side include for example the Media Independent Interface (MII) and the Gigabit Media Independent Interface (GMII).

On the optical interface side, there has not been a standard solution. The fundamental requirement for a multi-rate optical transceiver is to enable the transceiver to transmit and receive optical signals using a variable input power and a variable output power that satisfy the requirements from various industry standards. In particular, the electrical-to-optical converter needs to output optical signals at a variable output power. The optical-to-electrical converter needs to operate at different sensitivities, in [reflect] *respect* of different input powers for different data rates.

[Refer] *Referring* to FIG. **3**, a block diagram illustrating the transmission and reception paths of an optical transceiver *300 is shown*. In the transmission path, the optical transceiver **300** receives a second electrical signal **330** (also referred to as an electrical transmission signal). The electrical transmission signal **330** goes through block **312**, which generates a driver current for electrical to optical converter **311**. Block **312** also generates a bias voltage for the electrical to optical converter **311**. The driver current and the bias voltage are controlled by *a* micro-controller **313**. The electrical to optical converter **311** generates a second optical signal **360** (also referred to as an optical transmission signal). The optical transmission signal **360** is monitored by monitoring photo-diode **317**, which sends a feedback signal through feedback control line **319** to driver **312**, so that the bias voltage and driving current can be modified. When there is a change in data rate at the electrical transmission signal **330**, the data rate of the optical transmission output signal **360** can be changed by a user command line **340**. Through the user command line **340**, a control signal is sent to micro-controller **313**. The micro-controller **313** controls the driver **312** that produces *the* bias voltage and driving current for electrical to optical converter **311**. Different bias voltages and driving currents can cause the electrical to optical converter **311** to produce different output [power] *powers* for the optical transmission signal **360**.

The output power of the optical output signal **360** can be further controlled by [a] *an* optical feedback signal through the feedback control line **319**. A monitoring photo diode **317** receives and monitors the intensity of the monitoring optical signal **321** from the electrical to optical converter **311** and produces the feedback control signal in accordance with the intensity of the monitoring optical signal **321**. The feedback signal can adjust the bias voltage or driving current of block **312** to control the output power of the optical transmission signal **360**.

In the reception path, the optical transceiver **300** takes a first optical signal (i.e. the optical reception signal) **350**, and the optical reception signal **350** is converted to a first electrical signal (i.e. the reception electrical signal) at optical-to-electrical converter **314**. The converted electrical signal is amplified by Trans-Impedance Amplifier (TIA) **315**, followed by a limiting amplifier **316**. The amplification can be modified by TIA bandwidth controller **318**.

When there is a change in the data rate in the optical reception signal **350**, the sensitivity for the optical reception signal **350** needs to be modified to fit the reception data rate. This is done by the bandwidth controller user command input **370**. This control signal is received by bandwidth controller **318**, which controls the bandwidth of the Trans-Impedance Amplifier **315**. Different bandwidth at the TIA **315** makes the sensitivity of the electrical signal from the optical-to-electrical converter **314** different. Thus the optical transceiver **300** can be adjusted to receive data at different data rates.

A variety of implementations exist for the control lines **340** and **370**. Control lines **340** and **370** can be a single control that can set data transmission and reception at the same data rate. Alternatively, the control lines **340** and **370** can be implemented by two separate control lines, allowing different data rates for data transmission and reception. In one implementation of the control lines **340** and **370**, the control lines simply send a "mode" signal, informing the optical transceiver the desired data rate to be set. Once the mode signal is received, the optical transceiver is programmed to automatically set the operation parameters to a set of pre-determined values such that the proper data rate can be achieved. The "mode" signals can be prepared and stored in one of the following forms:

1. a programmable logic such as CPLD or FPGA
2. a memory device, such as EEPROM
3. a micro-controller (with **[**build**]** *built* in memory to store software instruction)

In another implementation of the control lines **340** and **370**, the controls are achieved through an "in-band" hand-shaking from the optical interface. The operation mode of the optical transceiver is determined through this hand shake optical interface, by an intelligent data processing unit so that the optical transceiver can be set at the proper data rate through the "remote" provisioning by the link party at the far side.

FIG. **4** illustrates another optical transceiver **400**. In the transmission path, the optical transceiver **400** receives an electrical transmission signal at a Physical Coding Sublayer (PCS) block **420** which in turn transmits the electrical transmission signal to a Physical Media Attachment (PMA) block **419**. The electrical transmission signal from the PMA block **419** goes through block **412**, which generates a driver current for electrical to optical converter **411**. Block **412** also generates a bias voltage for the electrical to optical converter **411**. The driver current and the bias voltage are controlled by micro-controller **413**. The electrical to optical converter **411** generates an optical transmission signal **470**. The optical transmission signal **470** is monitored by monitoring photo-diode **417**, which sends a feedback signal through feedback control line **490** to driver **412**, so that the bias voltage and driving current can be modified.

When there is a change in data rate at the electrical transmission signal **[430]** *440*, the data rate of the optical transmission output signal **470** can be changed by a user command line **450**. Through the user command line **450**, a control signal is sent to micro-controller **413**, which controls the driver **412** which in turn produces the bias voltage and driving current for electrical to optical converter **411**. Different bias voltages and driving currents cause the electrical to optical converter **411** to produce different output power for the optical transmission signal **470**.

The output power of the optical output signal **470** can be further regulated by setting different values to an EEPROM POT in the control feedback loop **[**. . .**]** by the optical feedback signal through the feedback control line **490**, which is generated by monitoring photo diode **417**. The monitoring photo diode **417** receives and monitors the strength of a monitoring optical signal **421** from the electrical to optical converter **411**. Based on the strength of the monitoring optical signal **421**, the monitoring photo-diode **417** produces the feedback control signal on the feedback control line **490**. The feedback signal reduces or increases the bias voltage or driving current of block **412**, which results in a reduction or increase in the output power of the optical transmission signal **470**.

In the reception path, the optical transceiver **400** receives an optical reception signal **460**, and the optical reception signal **460** is converted to a reception electrical signal at optical-to-electrical converter **414**. The converted electrical reception signal is amplified by Trans-Impedance Amplifier (TIA) **415**, followed by a limiting amplifier **416**. The amplification can be modified by TIA bandwidth controller **418**.

When there is a change in the data rate in the optical reception signal **460**, the optical reception signal **460** is modified to fit the reception data rate by adjusting controller user command input **480** to the bandwidth controller. Based on the user command input **480**, the bandwidth of Trans-Impedance amplifier **415** can be modified. Different bandwidths at the TIA **415** can result in different sensitivities to the electrical signal in the optical-to-electrical converter **414**. Thus the optical transceiver **400** can be adjusted to receive data at different data rates.

The PMA **419** and PCS **420** are electric circuits that enable in the compatibility with the Ethernet standards such as the Media Independent Interface (MII) standard or the Gigabit Media Independent Interface (GMII). With the configuration in FIG. **4**, the interface of signals **430** and **440** become "universal" with any GMII (Gigabit Media Independent Interface) type of interfaces. With a GMII interface, data can be transmitted at different data rate such as 100 Mbps or Gigabit Ethernet through the same interface without any need for changing the physical optical interface device. This is achieved by integrating the intelligence of switching the operation mode of PHY also inside the transceiver. Data Encoding and Decoding can be conducted without any physical change. For example 100 M Ethernet requires 4B/5B CODEC while Gigabit Ethernet requires 8B/10B CODEC. With this "switchable" function integrated into the optical transceiver, it becomes a "universal device" for running both Fast Ethernet and Gigabit Ethernet. A user can attach this device to their MII or GMII based MAC interface and set data rate by software commands without changing the physical configuration of the device.

In another embodiment, the optical transceiver's transmission and reception data rates can be detected and the optical transceiver's operation mode can be set automatically based on the detected transmit and reception data rates. FIG. **5** shows the block diagram for an optical transceiver **500**. As *for* optical transceiver **400**, optical transceiver **500** has a Physical Coding Sublayer (PCS) block **520** at its electrical interface. At this interface, electrical transmission signal **540** enters the PCS **520** and electrical reception signal **530** is sent out by the PCS **520**. The PCS **520** is coupled with a Physical Media Attachment (PMA) block **519**. The combination of the PCS **520** and the PMA **519** makes the electrical interface a standard Ethernet interface making it possible for the optical transceiver to be connected directly to an Ethernet Media Access Controller (MAC) block.

On the optical interface, the optical transmission signal **570** is the output from the electrical-to-optical converter **511**. The optical reception signal **560** enters the optical-to-electrical converter **514**. The major control of the output power of optical transmission signal **570** is from control input **550**, and a fine tune control signal **590** comes from monitoring photo-diode **517**. The control of the input sensitivity of optical reception signal **560** is through bandwidth controller **518**, which is controlled by control signal **581**. Unlike **[**ptical**]** *optical* transceiver **400**, whose data rate is entirely controlled by user command lines, optical transceiver **500** can detect the data rates at the electrical transmission signal **540** and the reception optical signal **560**.

In the transmission direction, the transmission data rate detector **521** detects the electrical transmission signal **540** and measures the transmission signal data rate. One possible implementation of the data rate detector **521** can comprise a clock recovery circuit and a counter. The counter of clock cycles is an indication of the data rate. Based on the measured transmission signal data rate, the transmission data rate detector **521** generates a Micro-controller data rate set up input signal **550** and sends this control signal to micro-controller **513**.

In the data-reception path, the reception data rate detector **580** receives the electrical reception signal from output of the optical-to-electrical converter **514** and measures the data rate of this signal. Based on the measured data rate of the input optical data, the reception data rate detector **580** generates a bandwidth controller set up input **581**, and sends this control signal to bandwidth controller **518**. With the detection of the transmission and reception data rates, the data rates of the optical transceiver **500** can be automatically set by the data rate detectors **521** and **580**, thus the user command lines can be eliminated.

The disclosed system includes the following advantages over the conventional single-data-rate optical transceiver: (1) A multi-rate optical transceiver makes it possible to a network to operate at different data rates or for networks or computer devices operating at different data rates to communicate with each other. (2) A multi-rate optical transceiver makes it more convenient to upgrade a network from one data rate to a higher data rate. No unplugging and plugging of optical transceivers on a network is needed during a data rate upgrade. (3) A multi-rate optical transceiver is more cost efficient. The multi-rate optical transceiver can operate on multiple data rates, while several conventional single-data-rate optical transceivers are required to operate at different data rates.

PART NUMBERS

100 optical transceiver module
110 module housing
120 shielding metal cover
130 electrical interface
140 optical interface
200 a chart for average input and output powers of 100 Mbps and 1000 Mbps Ethernet
311 Electrical to optical converter device
312 driver circuits
313 micro-controller/EEPOT
314 optical-to-electrical converter
315 trans-impedance amplifier
316 limiting amplifier
317 monitoring photo-diode
318 trans-impedance amplifier bandwidth control
319 feedback control line
320 electrical signal output
321 monitoring optical signal
330 electrical signal input
340 micro-controller user command input
350 optical signal input
360 optical signal output
370 bandwidth controller user command input
411 electrical to optical converter device
412 driver circuits
413 micro-controller/EEPOT
414 optical-to-electrical converter
415 trans-impedance amplifier
416 limiting amplifier
417 Monitoring photo-diode
418 Trans-impedance amplifier bandwidth control
419 Physical Media Attachment (PMA)
420 Physical Coding Sublayer (PCS)
430 Media Independent Interface (MII) electrical signal output
440 Media Independent Interface (MII) electrical signal input
450 Micro-controller user command input line
460 Optical signal input
470 optical signal output
480 bandwidth controller user command input
490 feedback control line
511 electrical to optical converter device
512 driver circuits
513 micro-controller/EEPOT
514 optical-to-electrical converter
515 trans-impedance amplifier
516 limiting amplifier
517 monitoring photo-diode
518 trans-impedance amplifier bandwidth control
519 Physical Media Attachment (PMA)
520 Physical Coding Sublayer (PCS)
521 **[**Rx**]** *Tx* data rate detector
530 Media Dependent Interface electrical signal output
540 Media Dependent Interface electrical signal input
550 Micro-controller data rate set up input
560 optical signal input
570 optical signal output
580 **[**Tx**]** *Rx* data rate detector
581 Bandwidth controller set up input
590 fine tune control signal

What is claimed is:

1. An optical transceiver that receives and transmits signals of various data rates and power levels, comprising:

an electrical interface comprising an electrical input port that receives an input electrical signal, a first user command input port that receives a first user command signal, an electrical output port that outputs an electrical output signal and a second user command input port that receives a second user command signal;

an optical interface comprising an optical input port that receives an input optical signal based on which the electrical output signal is generated at the electrical interface, and an optical output port that outputs an optical output signal based on the electrical input signal received at the electrical interface;

a driver circuit coupled to the electrical input port to receive the electrical input signal and responsive to a control of the first user command signal in converting the electrical input signal into a driver signal at a data rate that is based on and varies with the first user command signal, the driver circuit coupled to receive a power feedback control signal and controlling a power level of the driver signal based on the received power feedback control signal;

an electrical to optical converter coupled to the driver circuit to convert the driver signal into the optical output signal carrying data of the driver signal at the data rate;

a monitoring photo diode that detects light of the optical output signal to generate the power feedback control signal to the driver circuit;

an optical to electrical converter coupled to the optical input port and converting the input optical signal into a first electrical signal;

an amplifier coupled to the optical to electrical converter to receive and amplify the first electrical signal to generate the output electrical signal, the amplifier receiving a bandwidth control signal and adjusting a bandwidth of the amplifier in generating the output electrical signal in response to the bandwidth control signal; and

a bandwidth controller coupled to receive the second user command signal and producing the bandwidth control signal based on the second user command signal.

2. The optical transceiver as in claim **1**, wherein the electrical interface comprises a Physical Media Attachment block (PMA) coupled to the amplifier and the driver circuit, configured to receive the output from the amplifier and to transmit the input electrical signal to the driver circuit.

3. The optical transceiver as in claim **2**, wherein the electrical interface comprises a Physical Coding Sublayer block (PCS) coupled to the Physical Media Attachment block (PMA), configured to receive output from the Physical Media Attachment block and *transmits* the input electrical signal to the Physical Media Attachment block.

4. An optical transceiver that receives and transmits signals of various data rates and power levels, comprising:

an electrical interface comprising an electrical input port that receives an input electrical signal, and an electrical output port that outputs an electrical output signal;

an optical interface comprising an optical input port that receives an input optical signal based on which the electrical output signal is generated at the electrical interface, and an optical output port that outputs an optical output signal based on the electrical input signal received at the electrical interface;

a driver circuit coupled to the electrical input port to receive the electrical input signal and responsive to a transmitter data control signal in converting the electrical input signal into a driver signal at a data rate that is based on and varies with the transmitter data control signal, the driver circuit coupled to receive a power feedback control signal and controlling a power level of the driver signal based on the received power feedback control signal;

a transmitter data rate detector coupled to detect a data rate of the input electrical signal and producing the transmitter data control signal;

an electrical to optical converter coupled to the driver circuit to convert the driver signal into the optical output signal carrying data of the driver signal at the data rate;

a monitoring photo diode that detects light of the optical output signal to generate the power feedback control signal to the driver circuit;

an optical to electrical converter coupled to the optical input port and converting the input optical signal into a first electrical signal;

an amplifier coupled to the optical to electrical converter to receive and amplify the first electrical signal to generate the output electrical signal, the amplifier receiving a bandwidth control signal and adjusting a bandwidth of the amplifier in generating the output electrical signal in response to the bandwidth control signal;

a receiver data rate detector coupled to detect a data rate of the first electrical signal output by the optical to electrical converter and producing the receiver data control signal based on the detected data rate; and

a bandwidth controller coupled to receive the receiver data control signal and producing the bandwidth control signal based on the receiver data control signal.

5. The optical transceiver as in claim **4**, wherein the electrical interface comprises a Physical Media Attachment block (PMA) coupled to the amplifier and the driver circuit, configured to receive the output from the amplifier and to transmit the input electrical signal to the driver circuit.

6. The optical transceiver as in claim **5**, wherein the electrical interface comprises a Physical Coding Sublayer block (PCS) coupled to the Physical Media Attachment block (PMA), configured to receive output from the Physical Media Attachment block and transmits the input electrical signal to the Physical Media Attachment block.

7. An optical transceiver, comprising:

an electrical interface that receives an input electrical signal and that outputs an electrical output signal;

an optical interface that receives an input optical signal on which the electrical output signal is based and that outputs an optical output signal based on the electrical input signal;

a driver circuit that converts the electrical input signal into a driver signal, the driver circuit generating the driver signal at a power that is based on a feedback control signal;

an electrical to optical converter coupled to the driver circuit to convert the driver signal into the optical output signal, the optical output signal carrying data of the driver signal at a first data rate, the electrical to optical converter outputting the optical output signal at a variable output power controlled by a receiver data control signal;

a photo diode that monitors the optical output signal and generates the feedback control signal;

an optical to electrical converter that converts the input optical signal into a first electrical signal;

an amplifier coupled to the optical to electrical converter to amplify the first electrical signal and generate the output electrical signal, the amplifier having a modifiable bandwidth that is controlled by the receiver data control signal.

8. The optical transceiver as in claim 7, further comprising a receiver data rate detector coupled to detect a data rate of the first electrical signal, the receiver data rate detector producing the receiver data control signal based on the detected data rate of the first electrical signal.

9. The optical transceiver as in claim 7, wherein the receiver data control signal is controlled by software.

10. The optical transceiver as in claim 7, wherein the optical interface determines an operation mode for the optical transceiver through hand-shaking.

11. The optical transceiver as in claim 10, wherein the operation mode sets the first data rate and a data rate of the input optical signal through remote provisioning by a link party.

12. The optical transceiver as in claim 8, wherein the amplifier comprises (i) a transimpedance amplifier receiving the first electrical signal and providing an amplified electrical signal, and (ii) a limiting amplifier receiving the amplified electrical signal and providing the output electrical signal.

13. The optical transceiver as in claim 12, wherein the receiver data rate detector controls a bandwidth of the transimpedance amplifier, a difference in the bandwidth of the transimpedance amplifier results in a difference in sensitivity of the input optical signal, and the sensitivity of the input optical signal is modified to fit a data rate of the input optical signal.

14. The optical transceiver as in claim 8, wherein the receiver data rate detector is configured to control frequency response characteristics of the amplifier.

15. An optical transceiver, comprising:

an electrical interface that receives an input electrical signal and that outputs an electrical output signal;

an optical interface that receives an input optical signal on which the electrical output signal is based and that outputs an optical output signal based on the electrical input signal;

a driver circuit receiving the electrical input signal or a variation thereof, and producing a driver signal at a data rate that is based on and that varies with a transmitter data control signal, the driver circuit receiving a feedback control signal controlling a power of the driver signal;

an electrical to optical converter coupled to the driver circuit to convert the driver signal into the optical output signal, the electrical to optical converter outputting the optical output signal at a variable output power that is based on and that varies with the transmitter data control signal;

a photo diode that monitors the optical output signal and generates the feedback control signal;

an optical to electrical converter that converts the input optical signal into a first electrical signal;

an amplifier coupled to the optical to electrical converter, to receive and amplify the first electrical signal and generate the output electrical signal, the amplifier having a modifiable bandwidth that is controlled by a bandwidth control signal; and

a bandwidth controller coupled to receive the transmitter data control signal, the bandwidth controller producing the bandwidth control signal.

16. The optical transceiver as in claim 15, wherein the photo diode (i) monitors an intensity, power or strength of a monitoring optical signal from the electrical to optical converter and (ii) produces the feedback control signal in accordance with or based on the intensity or strength of the monitoring optical signal.

17. The optical transceiver as in claim 15, wherein the driver circuit produces a bias voltage and a driving current for the electrical to optical converter, and the feedback control signal is configured to modify or adjust the bias voltage and/or the driving current of the driver circuit to control the output power of the optical output signal.

18. The optical transceiver as in claim 17, wherein the output power of the optical output signal is regulated by an EEPROM having values set by the feedback control signal.

19. The optical transceiver as in claim 17, further comprising a micro-controller that controls the bias voltage and the driver current of the driver circuit.

20. The optical transceiver as in claim 19, wherein the electrical interface further comprises a user command input that receives a user command signal, and the micro-controller receives the user command signal.

21. The optical transceiver as in claim 19, wherein the micro-controller includes a memory to store software instructions.

22. The optical transceiver as in claim 19, further comprising a transmitter data rate detector coupled to detect a data rate of the electrical input signal and producing the transmitter data control signal based on the detected data rate of the first electrical signal.

23. The optical transceiver as in claim 15, wherein the transmitter data control signal is controlled by software.

24. An optical transceiver, comprising:

an electrical interface that receives an input electrical signal and that outputs an electrical output signal;

an optical interface that receives an input optical signal on which the electrical output signal is based and that outputs an optical output signal based on the electrical input signal;

a driver circuit receiving the electrical input signal or a variation thereof, and producing a driver signal at a data rate that is based on and that varies with a transmitter data control signal, the driver circuit receiving a feedback control signal controlling a power of the driver signal;

an electrical to optical converter coupled to the driver circuit to convert the driver signal into the optical output signal, the electrical to optical converter outputting the optical output signal at a variable output power that is based on and that varies with the transmitter data control signal;

a photo diode that monitors the optical output signal and that generates the feedback control signal;

an optical to electrical converter that converts the input optical signal into a first electrical signal;

an amplifier coupled to the optical to electrical converter to amplify the first electrical signal and generate the output electrical signal, the amplifier having a modifiable bandwidth that is controlled by a bandwidth control signal; and

a bandwidth controller coupled to receive a receiver data control signal, the bandwidth controller producing the bandwidth control signal.

25. The optical transceiver as in claim 24, wherein a change in data rate of the input optical signal changes the bandwidth of the amplifier, and a change in the transmitter data control signal changes a data rate and power of the optical output signal.

26. The optical transceiver as in claim 24, wherein the electrical interface further comprises a user command input that receives a user command signal.

27. The optical transceiver as in claim 26, wherein the user command signal consists of a single control signal that sets data transmission and data reception at a same rate.

28. The optical transceiver as in claim 26, wherein the user command signal comprises first and second control lines that allow different data rates for data transmission and data reception.

29. The optical transceiver as in claim 28, further comprising a micro-controller that receives the transmitter data control signal on the first control line, wherein the bandwidth controller receives a second user command signal on the second control line, the bandwidth controller producing the bandwidth control signal based on the second user command signal.

30. The optical transceiver as in claim 24, further comprising:

a) a receiver data rate detector coupled to detect a data rate of the first electrical signal, the receiver data rate detector producing a receiver data control signal based on the detected data rate of the first electrical signal, and *the bandwidth controller producing the bandwidth control signal based on the receiver data control signal;*

b) a transmitter data rate detector coupled to detect a data rate of the electrical input signal and producing a data rate set up signal; and

c) a micro-controller that receives the data rate set up signal and controls a bias voltage and a driving current of the driver circuit.

31. The optical transceiver as in claim 24, wherein the bandwidth control signal is controlled by software.

32. The optical transceiver as in claim 24, wherein the optical interface determines an operation mode for the optical transceiver through hand-shaking, and the operation mode sets the first data rate and a data rate of the input optical signal through remote provisioning by a link party.

33. The optical transceiver as in claim 24, wherein the amplifier comprises:

a) a transimpedance amplifier receiving the first electrical signal and providing an amplified electrical signal, wherein the bandwidth controller controls a bandwidth of the transimpedance amplifier, and

b) a limiting amplifier receiving the amplified electrical signal and providing the output electrical signal.

34. The optical transceiver as in claim 24, wherein the bandwidth controller is configured to control frequency response characteristics of the amplifier.

35. A method of receiving and transmitting optical signals, comprising:

converting an electrical input signal into a driver signal at a data rate that is based on and that varies with a first command signal;

converting the driver signal into an optical output signal and at a variable output power that is based on and that varies with the first command signal, the optical output signal carrying data of the driver signal;

converting an input optical signal into a first electrical signal; and

amplifying the first electrical signal to generate an output electrical signal, the first electrical signal having a modifiable bandwidth that is controlled by a second command signal.

36. The method as in claim 35, wherein a difference in the modifiable bandwidth of the first electrical signal results in a difference in sensitivity of the input optical signal, and the sensitivity of the input optical signal is modified to fit a data rate of the input optical signal.

37. The method as in claim 35, wherein the first command signal and the second command signal are represented by one or more mode signals that set desired data rates for data transmission and data reception.

38. The method as in claim 35, wherein a change in the first command signal changes a data rate of the optical output signal, and a change in the second command signal changes a data rate of the optical input signal.

39. The method as in claim 35, wherein the power of the driver signal corresponds to a bias voltage and a driving current, and the method further comprises controlling a power of the driver signal based on a feedback control signal, the feedback control signal adjusting the bias voltage and/or the driving current to control an output power of the optical output signal.

40. The method as in claim 35, further comprising determining an operation mode for the optical transceiver through hand-shaking.

41. The method as in claim 40, wherein the operation mode sets the data rates of the driver signal and the input optical signal through remote provisioning by a link party.

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