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(71) Applicant *(for all designated States except US)*: **TEXAS INSTRUMENTS INCORPORATED** [US/US]; P. O. Box 655474, Mail Station 3999, Dallas, TX 75265-5474 (US).

(71) Applicant *(for JP only)*: **TEXAS INSTRUMENTS JAPAN LIMITED** [JP/JP]; 24-1, Nishi-shinjuku 6 Chome, Shinjuku-ku, Tokyo, 160-8366 (JP).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SHALITA, Oren** [IL/IL]; Drezner 4, 69767 Tel Aviv (IL). **CHAIKINK, Sholomy** [IL/IL]; 2 Hazivoni St., 73160 Moshav Mazor (IL).

(74) Agents: **FRANZ, Warren, L.** et al.; Texas Instruments Incorporated, P. O. Box 655474, Mail Station 3999, Dallas, TX 75265-5474 (US).

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(54) **Title**: POWER BACK-OFF MODE CIRCUIT FOR 100BASET

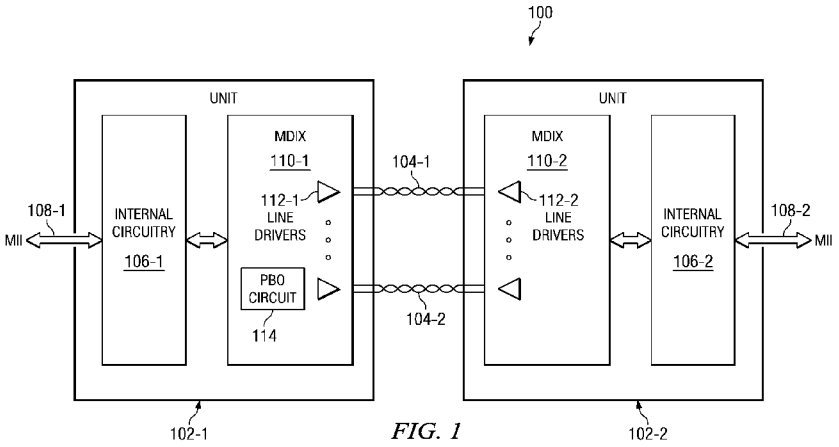

FIG. 1

(57) **Abstract**: Generally, 100BaseT allows for the establishment of links on cables (such as Category 5 or CAT5 cables) up to 120m or more in length. In a given industrial Ethernet system, many of the cables deployed will be less than 120m in length, and, in fact, many of the cables are much shorter than 120m. Yet, the transmission amplitude output from each unit is generally the same, regardless of cable length. A described system includes power back-off (PBO) circuitry (114) to estimate cable length of twisted-paris (104) based on transmitted idles and adjust transmission amplitudes for units (102) coupled over a twisted-pair 100BaseT Ethernet connection so as to reduce power consumption. The PBO employs a passive correlation algorithm.

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POWER BACK-OFF MODE AND CIRCUIT FOR 100BASET

[0001] The invention relates generally to Ethernet and, more particularly, to a power back-off (PBO) mode and circuit for 100BaseT Ethernet.

BACKGROUND

[0002] Currently, there are numerous Institute of Electrical and Electronics Engineers (IEEE) standards for Ethernet. Some examples are 10BaseT, 100BaseT, and 1000BaseT, which are enumerated and described for several different types of transmission media (i.e., twisted-pair). Specifically, though, 100BaseT for twisted-pairs (which is described by IEEE 802.3u and that is hereby incorporated by reference for all purposes) has largely fallen into disuse in favor of higher speed standards (i.e., 1000BaseT) with exception to many industrial applications. In other words, 100BaseT is still widely used for industrial Ethernet.

[0003] Generally, 100BaseT allows for the establishment of links on cables (such as Category 5 or CAT5 cables) up to 120m or more in length. In a given industrial Ethernet system, many of the cables deployed will be less than 120m in length, and, in fact, many of the cables are much shorter than 120m. Yet, the transmission amplitude output from each unit is generally the same, regardless of cable length. Usually, in these shorter cables the 100BaseT physical layer (PHY) attenuates incoming signals, resulting in wasted power on transmission. Because of the limited and relatively small market for 100BaseT, there has been very little development, even though there are problems that exist (such as wasted power on transmission). Thus, there is a need for a system that more efficiently uses power over 100BaseT connections.

[0004] An example of conventional systems is described in PCT Publ. No. WO08/027671.

SUMMARY

[0005] An example embodiment of the invention, accordingly, provides a method. The method comprises initiating a power back-off (PBO) mode for one of a plurality of units coupled to one another over a twisted-pair so as to communicate over a 100BaseT connection;

converging a cable length estimation during the link up period by: transmitting idles; detecting energy from transmitted idles; and calculating the length of the twisted pair so as to generate the cable length estimation; and selecting one of a plurality of predetermined transmission amplitudes that corresponds to the cable length estimation.

[0006] In accordance with an example embodiment of the invention, the step of initiating the PBO mode further comprises: initiating a drop link sequence (DLS); determining if a drop link counter has be been reset; and detecting energy transmitted across the twisted-pair if the drop link counter has been reset to begin a link up period.

[0007] In accordance with an example embodiment of the invention, the link up period is greater than 500μs.

[0008] In accordance with an example embodiment of the invention, the method further comprises remaining silent for a link down period following the link up period.

[0009] In accordance with an example embodiment of the invention, the link down period is greater than 750ms.

[0010] In accordance with an example embodiment of the invention, the step of initiating further comprises: resolving a link to 100BaseT, if in auto-negotiation mode; and initiating a DLS, after the step of resolving.

[0011] In accordance with an example embodiment of the invention, the step of initiating further comprises: determining if an energy detector indicator is raised in force mode; and initiating a DLS if the energy detector indicator is raised.

[0012] In accordance with an example embodiment of the invention, the plurality of transmission amplitudes are 0.4V, 0.6V, 0.8V, and 1.0V.

[0013] In accordance with an example embodiment of the invention, an apparatus is provided. The apparatus comprises means for initiating a power back-off (PBO) mode for one of a plurality of units coupled to one another over a twisted-pair so as to communicate over a 100BaseT connection;; means for converging a cable length estimation during the link up period that: transmits idles; detects energy from transmitted idles; and calculates the length of the twisted pair so as to generate the cable length estimation; and means for selecting one of a plurality of predetermined transmission amplitudes that corresponds to the cable length estimation.

[0014] In accordance with an example embodiment of the invention, the means for initiating the PBO mode further comprises: means for initiating a drop link sequence (DLS); means for determining if a drop link counter has be been reset; and means for detecting energy transmitted across the twisted-pair if the drop link counter has been reset to begin a link up period.

[0015] In accordance with an example embodiment of the invention, the means for initiating further comprises: means for resolving a link to 100BaseT, if in auto-negotiation mode; and means for initiating a DLS, after the step of resolving.

[0016] In accordance with an example embodiment of the invention, the means for initiating further comprises: means for determining if an energy detector indicator is raised in force mode; and means for initiating a DLS if the energy detector indicator is raised.

[0017] In accordance with an example embodiment of the invention, a first unit; a cable having a plurality of twisted-pairs that are each coupled to the first unit; and a second unit that is coupled to each of the twisted-pairs, wherein the second unit communicates with the first unit through a 100BaseT link over the plurality of twisted-pairs, and wherein the second unit includes: a plurality of line drivers that are each configured to transmit signals over at least one of the twisted pairs; means for initiating a DLS having: means for resolving a link to 100BaseT, if in auto-negotiation mode; and means for initiating a DLS, after the step of resolving; means for determining if a drop link counter has be been reset; means for detecting energy transmitted across a twisted-pair if the drop link counter has been reset to begin a link up period; means for converging a cable length estimation during the link up period that: transmits idles; detects energy from transmitted idles; and calculates the length of the twisted pair so as to generate the cable length estimation; means for selecting one of a plurality of predetermined transmission amplitudes that corresponds to the cable length estimation, wherein the plurality of transmission amplitudes are 0.4V, 0.6V, 0.8V, and 1.0V; means for remaining silent for a link down period following the link up period

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Example embodiments are described with reference to accompanying drawings, wherein:

[0019] FIG. 1 is a system in accordance with an example embodiment of the invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0020] In FIG. 1, the reference numeral 100 generally designates an example of a system in accordance with an example embodiment of the invention. System 100 is generally an Ethernet system having units 102-1 and 102-2 that communicate with one another over twisted-pairs 104-1 and 104-2 via a 100BaseT connection. Typically, twisted pairs 104-1 and 104-2 can be category 5 or CAT5 cables, which can be as long as 120m (or more). The units 102-1 and 102-2 also generally communicate with their respective media independent interfaces (MIIs) 108-1 and 108-2.

[0021] Each of these units 102-1 and 102-2 includes a several subcomponents (which may be included on a single integrated circuit or IC) that enable the 100BaseT physical layer (PHY) to establish a 100BaseT link. In particular, the units 102-1 and 102-2 respectively comprise medium dependent interfaces (MDIs) or medium dependent interface crossbars (MDIXs) 110-1 and 110-2 and internal circuitry 106-1 and 106-2.

[0022] Each of the MDIXs 110-1 and 110-2 include line drivers 112-1 and 112-2 to drive signals (including idles or idle signals). In conventional 100BaseT systems, the line drivers 112-1 and 112-2 would be have the transmission amplitudes always set to transmit over the maximum rated length (i.e., 120m), which wastes power the twisted-pairs 104-1 and 104-2 (and their corresponding cable) is shorter than the maximum rated length. To address this shortcoming, MDIX 110-1 includes a state machine or power back-off (PBO) circuit 114; MDIX 110-2 may also include a PBO circuit. PBO circuit 114 is able to identify the PBO scenario and establish a 100BaseT link (with any other 100BaseT unit regardless of whether includes a PBO circuit similar to PBO circuit 114) using reduced power, all while maintaining link quality.

[0023] To generally ensure that the PBO circuit 114 can be fully automated and operate independently of circuitry in unit 102-2 in a PBO mode, PBO circuit 114 should be able to identify and adapt to various link scenarios for a dropped link. These scenarios are based on whether units 102-1 and 102-2 are in auto-negotiation mode or in force mode (deliberate link drop); there are four permutations.

[0024] In DLS mode, if either of the units 102-1 or 102-2 are in auto-negotiation mode, the link is resolved to 100BaseT prior to initiation of the DLS, and if both units 102-1 or 102-2 are in force mode, then DLS is initiated when the energy detector indicator is raised. To accomplish this, PBO circuit 114 employs a drop link counter that assists in distinguishing the

scenarios. Essentially, the drop link counter operates to determine whether either unit 102-1 and/or unit 102-2 is in auto-negotiation mode. The drop link counter does this by counting over a predetermined period (which can be several seconds in length) and is triggered when energy is detected while the drop link counter is at 0. Generally, the predetermined length of the drop link counter (which generally defines the length of a Drop Link Sequence or DLS) is longer than the longest or "worst case" DLS, which generally ensures that a deadlock is avoided. A disadvantage of this drop link counter is that it generally defines the resolution for a "real" link drop. During a DLS (for the duration of the predetermined period), a "real" link drop is not detectable since every link failure during a DLS is considered part of the DLS.

[0025] In operation, the DLS can determine or suggest an amplitude for a given length of cable (i.e., length of twisted-pairs 104-1 and 104-2). A DLS begins when the drop link timer is 0 or has been reset and energy from a signal transmitted across the cable is detected. When the DLS begins, a link up period for the DLS begins, which occurs for a predetermined period that is maintained by a link up counter. During about the first 500μs to about 1ms of the link up period, idles are transmitted by both units 102-1 and 102-2 over the cable or twisted-pairs 104-1 and 104-2 and detected. Based on the detected idles, the PBO circuit 114 can calculate the length of cable (i.e., length of twisted-pairs 104-1 and 104-2) to generate or converge the cable length estimation. To make this estimation, however, PBO circuit employs a passive correlation algorithm. Analog front end or AFE parameter variance in unit 102-1, the cable length estimation is associated with a range of values, and the attenuation for the idles are matched with a set of ranges associated with a given cable length. For example, assuming that the cable (i.e., twisted-pairs 104-1 and 104-2) is a CAT5 cable and 120m is selected as the baseline length (or 0dB), a -4dB gain would correspond to a cable that is 105m in length. Following the link up period, there is a link down period (maintained by a link down counter) where unit 102-1 remains silent, which should be sufficiently long for the unit 102-2 to drop the link. Generally, the link down period is greater than 750ms.

[0026] Based on the estimated cable length, PBO circuit 114 can then set or suggest a corresponding transmission amplitude. Generally, there are several transmission amplitudes for the PBO circuit 114 to choose from, where each transmission amplitude would correspond to a range of lengths. For example, a set transmission amplitudes that are associated with "worst case" lengths can be seen below in Table 1, where 120m is the baseline length.

Table 1

Gain (dB)	Worst Case Length (m)	Transmission Amplitude (V)
-10	30	0.4
-9	40	0.4
-8	55	0.6
-7	65	0.6
-6	85	0.6
-5	100	0.8
-4	105	0.8
-3	130	1.0
-2	145	1.0
-1	150	1.0
0	150	1.0
1	150	1.0
2	150	1.0
3	150	1.0

Thus, PBO circuit 114 is able to lower the transmission amplitude to correspond to the cable length so as to reduce power consumption.

[0027] Another option for establishing a PBO link is using the Quick PBO mode. During the Quick PBO mode, unit 102-1 assumes that the gain adjustment mechanism of unit 102-2 operates more than 500 μs after the first detection of usable energy. As a result, unit 102-1 records the far end energy (i.e., energy of pulse transmitted from unit 104-2) and estimates, accordingly, the cable length and reduction in the transmission amplitude (using a similar algorithm to the DLS). Generally, an 'on the fly' transmission amplitude estimation is used, assuming that unit 104-2 will be able still to converge on the new, selected transmission amplitude. Afterwards, the startup and establish link with the new settings can continue. Therefore, the delay from the drop link time period can be saved.

[0028] Embodiments having different combinations of one or more of the features or steps described in the context of example embodiments having all or just some of such features or steps are intended to be covered hereby. Those skilled in the art will appreciate that many other embodiments and variations are also possible within the scope of the claimed invention.

CLAIMS

What is claimed is:

1. A method comprising:

initiating a power back-off (PBO) mode for one of a plurality of units coupled to one another over a twisted-pair so as to communicate over a 100BaseT connection;

converging a cable length estimation during the link up period by:

transmitting idles;

detecting energy from transmitted idles; and

calculating the length of the twisted pair so as to generate the cable length estimation; and

selecting one of a plurality of predetermined transmission amplitudes that corresponds to the cable length estimation.

2. The method of Claim 1, wherein the step of initiating the power back-off mode further comprises:

initiating a drop link sequence (DLS);

determining if a drop link counter has be been reset; and

detecting energy transmitted across the twisted-pair if the drop link counter has been reset to begin a link up period.

3. The method of Claim 2, wherein the link up period is greater than 500μs.

4. The method of Claim 2, wherein the method further comprises remaining silent for a link down period following the link up period.

5. The method of Claim 4, wherein the link down period is greater than 750ms.

6. The method of Claim 2, wherein the step of initiating further comprises:

resolving a link to 100BaseT, if in auto-negotiation mode; and

initiating a drop link sequence, after the step of resolving.

7. The method of Claim 2, wherein the step of initiating further comprises:

determining if an energy detector indicator is raised in force mode; and

initiating a drop link sequence if the energy detector indicator is raised.

8. The method of Claim 2, wherein the plurality of transmission amplitudes are 0.4V, 0.6V, 0.8V, and 1.0V.

9. The method of Claim 1, wherein the step of initiating the power back-off (PBO) mode further comprises:

initiating a Quick PBO mode;

initiating a 100BaseT link in the Quick PBO mode; and

detecting and recording energy transmitted across the twisted-pair during a record mode period.

10. An apparatus comprising:

means for initiating a power back-off (PBO) mode for one of a plurality of units coupled to one another over a twisted-pair so as to communicate over a 100BaseT connection;

means for converging a cable length estimation during the link up period that:

transmits idles;

detects energy from transmitted idles; and

calculates the length of the twisted pair so as to generate the cable length estimation; and

means for selecting one of a plurality of predetermined transmission amplitudes that corresponds to the cable length estimation.

11. The apparatus of Claim 10, wherein the step of initiating the PBO mode further comprises:

initiating a drop link sequence (DLS);

determining if a drop link counter has be been reset; and

detecting energy transmitted across the twisted-pair if the drop link counter has been reset to begin a link up period.

12. The apparatus of Claim 11, wherein the link up period is greater than 500μs.

13. The apparatus of Claim 11, wherein the method further comprises means for remaining silent for a link down period following the link up period.

14. The apparatus of Claim 13, wherein the link down period is greater than 750ms.

15. The apparatus of Claim 11, wherein the means for initiating further comprises:
means for resolving a link to 100BaseT, if in auto-negotiation mode; and
means for initiating a drop link sequence, after the step of resolving.

16. The apparatus of Claim 11, wherein the means for initiating further comprises:
means for determining if an energy detector indicator is raised in force mode; and
means for initiating a drop link sequence if the energy detector indicator is raised.

17. The apparatus of Claim 11, wherein the plurality of transmission amplitudes are 0.4V, 0.6V, 0.8V, and 1.0V.

18. The apparatus of Claim 10, wherein the means for initiating the power back-off mode further comprises:

means for initiating a Quick PBO mode;

initiating a 100BaseT link in the Quick PBO mode; and

detecting and recording energy transmitted across the twisted-pair during a record mode period.

19. An apparatus comprising:

a first unit;

a cable having a plurality of twisted-pairs that are each coupled to the first unit; and

a second unit that is coupled to each of the twisted-pairs, wherein the second unit communicates with the first unit through a 100BaseT link over the plurality of twisted-pairs, and wherein the second unit includes:

a plurality of line drivers that are each configured to transmit signals over at least one of the twisted pairs;

means for initiating a drop link sequence (DLS) having:

means for resolving a link to 100BaseT, if in auto-negotiation mode; and

means for initiating a drop link sequence, after the step of resolving;

means for determining if a drop link counter has be been reset;

means for detecting energy transmitted across a twisted-pair if the drop link counter has been reset to begin a link up period;

means for converging a cable length estimation during the link up period that:

transmits idles;

detects energy from transmitted idles; and

calculates the length of the twisted pair so as to generate the cable length estimation;

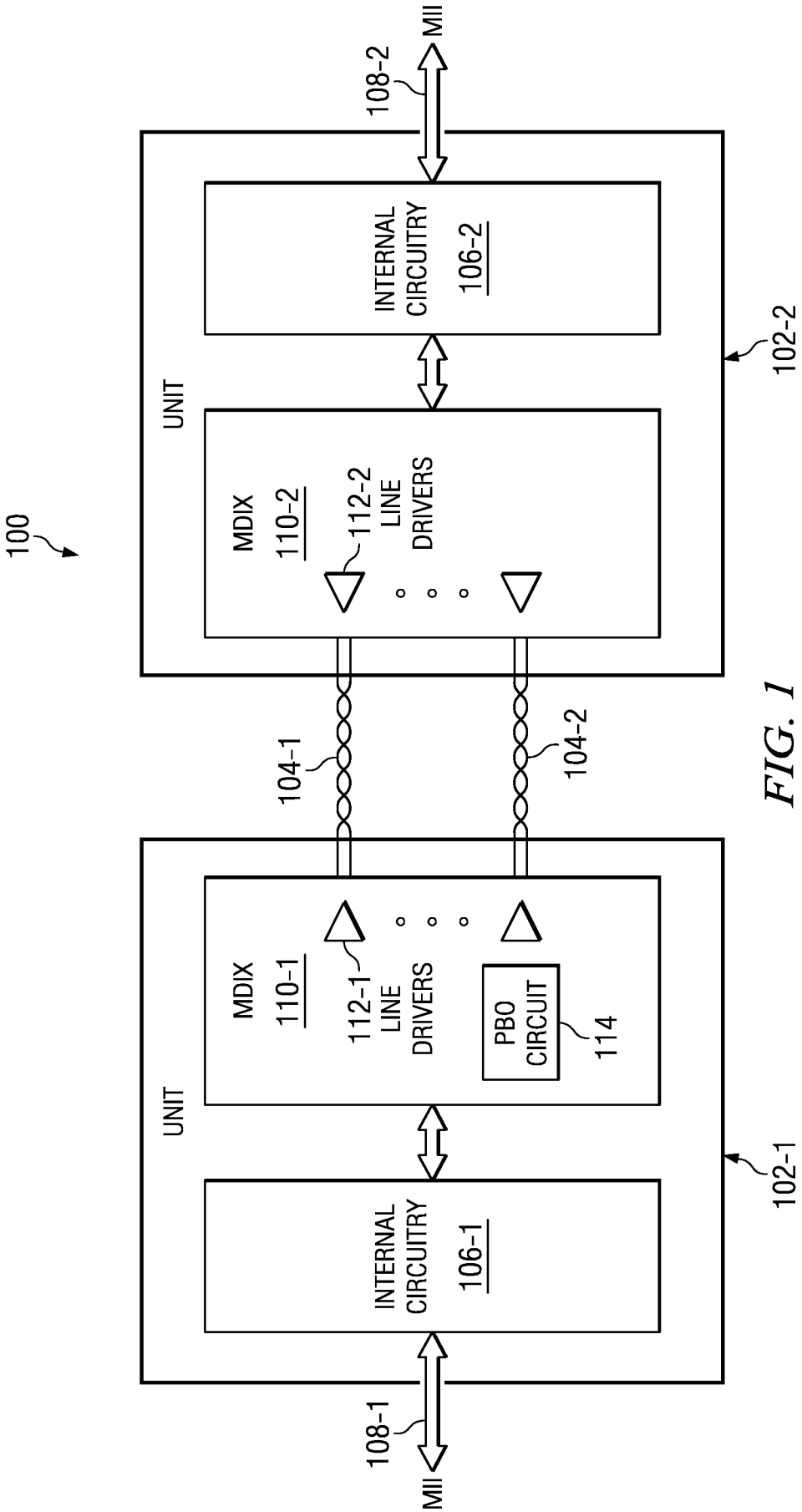
means for selecting one of a plurality of predetermined transmission amplitudes that corresponds to the cable length estimation, wherein the plurality of transmission amplitudes are 0.4V, 0.6V, 0.8V, and 1.0V; and

means for remaining silent for a link down period following the link up period.

20. The apparatus of Claim 19, wherein the means for initiating further comprises:

means for determining if an energy detector indicator is raised in force mode; and

means for initiating a drop link sequence if the energy detector indicator is raised.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102-1
108-1
MII

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/061494

A. CLASSIFICATION OF SUBJECT MATTER

H04L 12/28(2006.01)i, H04L 12/56(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L 12/28; H04J 3/06; H04B 1/44; H04L 12/66; H04L 12/413; H04M 1/24; H04M 3/22

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: cable length, amplitude, select, power backoff, 100baseT, drop link sequence, auto negotiation, drop link counter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007-0269022 A1 (DIMITRY TAICH et al.) 22 November 2007 See figs.2,4, paragraphs 25-28, 36-40 and claims 1-12	1,10
Y	US 2007-0140289 A1 (JOSE TELLADO et al.) 21 June 2007 See fig.5, paragraphs 3,25,31,51 and claims 39-41	1,10
A	US 2006-0023735 A1 (NIR SASSON) 02 February 2006 See paragraphs 10,17,28,32-34 and claims 1-6	1-20

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

☒ See patent family annex.

* Special categories of cited documents:

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Government Complex-Daejeon, 189 Cheongsa-ro,
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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