UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF ILLINOIS
EASTERN DIVISION

WESTELL TECHNOLOGIES, INC.,

Plaintiff,

v.

HYPEREDGE CORPORATION,

Defendant.

Civil Action No. 02-C-3496

Judge Joan B. Gottschall

Magistrate Judge Denlow

FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT AND DEMAND FOR JURY TRIAL
<u>INJUNCTIVE RELIEF REQUESTED</u>

NOW COMES Plaintiff Westell Technologies, Inc., by and through its undersigned attorneys, and for its Complaint avers as follows:

1. This is an action brought under the Patent Laws of the United States, 35 U.S.C. §§ 1 *et seq.*, for infringement of United States Patent No. 5,444,776 (the "'776 patent").

2. Plaintiff Westell Technologies, Inc. ("Westell") is a Delaware corporation with a principal place of business at 750 North Commons Drive, Aurora, Illinois 60504.

3. On information and belief, Defendant HyperEdge Corporation ("HyperEdge") is a Delaware corporation with a principal place of business at 940 Kingsland Drive, Batavia, Illinois 60510.

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JURISDICTION AND VENUE

4. This action for patent infringement arises under the acts of Congress relating to patents, namely the Patent Laws of the United States, 35 U.S.C. §§ 1 *et seq.*, and this Court thereby has jurisdiction over the subject matter pursuant to 28 U.S.C. §§ 1331 and 1338(a).

5. HyperEdge resides in this District, and this Court thereby has jurisdiction over HyperEdge's person generally. In addition, HyperEdge has committed acts of patent infringement in this District, and this Court thereby has jurisdiction over HyperEdge's person for this action.

6. This District is a proper venue for the bringing of this action pursuant to 28 U.S.C. §§ 1391(b) and 1400(b) because HyperEdge resides in this District and has committed acts of infringement and has a regular and established place of business in this District.

BACKGROUND

7. On August 22, 1995, the United States Patent and Trademark Office duly and legally issued the '776 patent, entitled "Bridge for a Network Interface Unit." Laurence L. Sheets and Daniel C. Peterson are the named inventors of the subject matter claimed in the '776 patent and, as of the date of the issuance of the '776 patent, had assigned their entire interest in the '776 patent to Teltrend Inc. ("Teltrend"). A true and correct copy of the '776 patent is attached hereto as Exhibit A.

8. Westell, as successor-in-interest to Teltrend, is the assignee of all right and title in the '776 patent.

9. The invention described in the '776 patent relates generally to the telecommunications industry. More specifically, the claims of the '776 patent are directed to a variety of network interface units and office repeaters that form part of an improved testing system for digital transmission lines. Digital transmission lines, such as twisted copper pairs of wires or fiber optic cables, form the backbone of the telecommunications system. A "network interface unit" is a device located at the point where customer equipment ends and network equipment begins that, among other things, provides a test access facility for network technicians. For example, a network interface unit may be found on the outside wall of a single family home. An "office repeater" is a device generally located within the central office of a telecommunications company that generates the current required to power line repeaters. The line repeaters then remove noise from a signal (whether voice or data communication) being transmitted along the digital transmission lines. An office repeater may also be located in a customer's premises if there is a long span between the central office and the customer's premises.

10. The network interface units and office repeaters claimed in the '776 patent improve the testing system of digital transmission lines by using passive impedances (including, for example, resistors) to reduce problems caused by open circuit reflection or voltage on a customer premises line. In addition, the claimed network interface units and office repeaters have a fast response time, allow for normal transmission under conditions of loss of local power, and do not consume excess power.

11. Because network interface units and office repeaters are used in digital transmission line infrastructure, their primary purchasers and users are telecommunications companies. More specifically, the "Baby Bell" companies who operate and maintain the digital transmission line infrastructure are the primary purchasers and users.

HYPEREDGE'S INFRINGING PRODUCTS

12. At all times since the founding of HyperEdge, its senior management has been well aware of Westell and its technology. Indeed, HyperEdge's president and chief executive officer, senior vice president of marketing and engineering, vice president of sales, and senior vice president of operations all formerly worked for Westell or Teltrend. As a result, on information and belief, HyperEdge has been aware of the '776 patent at all relevant times.

13. Despite its knowledge of the '776 patent, HyperEdge is making, using, offering for sale, and selling telecommunications equipment embodying the claims of the '776 patent. Among those infringing products is the HyperEdge 520-15SW. The HyperEdge 520-15SW is a network interface unit that uses passive impedances (specifically, resistors) to reduce problems caused by open circuit reflection and voltage on a customer premises line as described in the claims of the '776 patent. A copy of HyperEdge's website information on the HyperEdge 520-15SW, found at http://www.hyperedge.com/Pdf/520-15SWIssue1.pdf as of the date of this Amended Complaint, is attached hereto as Exhibit B.

PRE-FILING NEGOTIATIONS BETWEEN THE PARTIES

14. Because it desired to avoid any unnecessary conflict with its neighbor HyperEdge, Westell carefully investigated HyperEdge's potential infringement before approaching HyperEdge to negotiate over HyperEdge's infringement. That investigation, of the HyperEdge 520-15SW, showed clear infringement of several claims of the '776 patent. Because HyperEdge's equipment is sold primarily to telecommunications companies (and therefore unavailable to Westell directly), Westell was not able to investigate all of HyperEdge's network interface units and office repeaters.

15. Based on its determination that at least one of HyperEdge's products infringed the claims of the '776 patent, Westell's general counsel contacted HyperEdge's president and CEO with a February 1, 2002 letter requesting that HyperEdge cease and desist infringing the claims of the '776 patent. The letter further indicated Westell's "hope that [the parties] can avoid the expense and burden of litigation through an informal resolution of [the] matter." A copy of Westell's general counsel's February 1, 2002 letter is attached hereto as Exhibit C.

16. HyperEdge responded to Westell's general counsel's February 1, 2002 letter with a February 21, 2002 letter from its outside counsel, Timothy T. Patula. In his letter on behalf of HyperEdge, Mr. Patula stated, "[W]e have conducted a thorough investigation and have determined that none of HyperEdge's/Troncom's products infringe, or have ever infringed, the claims of U.S. Patent No. 5,444,776." A copy of Mr. Patula's February 21, 2002 letter is attached hereto as Exhibit D. Thus, as of at least February 21, 2002, before the filing of this action, HyperEdge's outside counsel was able to read the patent, examine HyperEdge's own actions, and discern a response to allegations of infringement of the '776 patent.

17. Based on Mr. Patula's forcefully expressed opinion, Westell returned to the question of infringement and again determined that at least the HyperEdge 520-15SW infringed claims of the '776 patent. Therefore, Westell's general counsel contacted Mr. Patula with an April 17, 2002 letter, in which Westell provided clear details of the known infringement and offered a license under the '776 patent to HyperEdge. A copy of Westell's general counsel's April 17, 2002 letter is attached hereto as Exhibit E.

18. Mr. Patula contacted Westell's general counsel by telephone to gain more time for HyperEdge to consider Westell's licensing offer. Eventually, however, Mr. Patula responded with a May 10, 2002 letter in which he rejected the possibility of any license and set forth specific claim elements from the independent claims of the '776 patent that he asserted HyperEdge's products lack. A copy of Mr. Patula's May 10, 2002 letter is attached hereto as Exhibit F. Mr. Patula's May 10, 2002 letter asserted that the HyperEdge 520-15SW, Issue 1 was discontinued. However, HyperEdge's website continues to identify and offer for sale the HyperEdge 520-15SW, Issue 1 as one of HyperEdge's current products. A screen print of the portion of HyperEdge's website found at http://www.hyperedge.com/index2.cfm as of the date of this Amended Complaint is attached hereto as Exhibit G. Mr. Patula's May 10, 2002 letter also stated, "we are highly confident that Westell's patent is invalid as being anticipated by, and/or obvious to one of ordinary skill in the art in view of well known prior art." Thus, as of at least May 10, 2002, HyperEdge was able to re-read the patent, investigate all of its products, and discern a response to allegations of infringement of the '776 patent, as well as review the patent's claims in light of the prior art.

COUNT I:
HYPEREDGE'S DIRECT PATENT INFRINGEMENT

19. Westell incorporates the allegations of paragraphs 1 through 18 as if set forth in full.

20. HyperEdge products, including the HyperEdge 520-15SW, incorporate all of the elements of claims of the '776 patent.

21. By virtue of its actions in making, using, offering for sale, and selling products incorporating all of the elements of claims of the '776 patent, including the HyperEdge 520-15SW, without authority or license from Westell, HyperEdge has directly infringed the '776 patent in violation of 35 U.S.C. §271(a).

22. On information and belief, HyperEdge's direct infringement of the '776 patent has been and continues to be willful and deliberate.

23 HyperEdge's direct infringement of the '776 patent has caused irreparable harm to Westell and will continue to cause irreparable harm to Westell unless enjoined.

COUNT II:
HYPEREDGE'S INDUCEMENT OF INFRINGEMENT BY OTHERS

24. Westell incorporates the allegations of paragraphs 1 through 23 as if set forth in full.

25. HyperEdge has actively induced others to use, offer for sale, and sell products incorporating all of the elements of claims of the '776 patent, including by distributing, offering for sale, and selling telecommunications equipment incorporating all of the elements of claims of the '776 patent with knowledge of how those infringing products would ultimately be used. The parties that HyperEdge has actively induced to infringe the claims of the '776 patent include its customers.

26. By virtue of its actions in actively inducing others to use, offer for sale, and sell products incorporating all of the elements of claims of the '776 patent without authority or license from Westell, HyperEdge has actively induced infringement of the '776 patent in violation of 35 U.S.C. §271(b).

27. On information and belief, HyperEdge's active inducement of infringement of the '776 patent has been and continues to be willful and deliberate.

28. HyperEdge's active inducement of infringement of the '776 patent has caused irreparable harm to Westell and will continue to cause irreparable harm to Westell unless enjoined.

RELIEF REQUESTED

WHEREFORE, Westell prays for judgment and relief including:

(A) Judgment that HyperEdge has been and is infringing one or more of the claims of Westell's '776 patent pursuant to 35 U.S.C. §§ 271(a) and (b);

(B) A preliminary and permanent injunction enjoining HyperEdge, its officers, agents, servants, employees, attorneys, and those in active concert or participation with HyperEdge from infringing or actively inducing infringement of the '776 patent;

(C) An award of damages incurred by Westell as a result of HyperEdge's infringement;

(D) An award trebling the damages pursuant to 35 U.S.C. § 284 as a result of HyperEdge's willful infringement of the '776 patent;

(E) An assessment of costs, including reasonable attorney fees pursuant to 35 U.S.C. § 285, and prejudgment interest against HyperEdge; and

(F) Such other and further relief as this Court may deem just and proper.

JURY DEMAND

Westell demands trial by jury on all issues so triable.

Respectfully submitted,

Dated: June 13, 2002

By: [signature]

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Marcus J. Thymian
Brian R. Harris
McDonnell Boehnen Hulbert & Berghoff
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Chicago, Illinois 60606
Tel.: (312) 913-0001
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Attorneys for Plaintiff,
WESTELL TECHNOLOGIES, INC.

CERTIFICATE OF SERVICE

I hereby certify that, on this 13th day of June, 2002, copies of the foregoing WESTELL'S FIRST AMENDED COMPLAINT AND DEMAND FOR JURY TRIAL and WESTELL'S RESPONSE TO HYPEREDGE'S MOTION TO DISMISS OR ALTERNATIVELY FOR MORE DEFINITE STATEMENT were served by facsimile (without exhibits) and by overnight mail (with exhibits) to the following:

Timothy T. Patula
Patula & Associates
116 South Michigan Avenue
Chicago, Illinois 60603
Telephone: 312-201-8220
Facsimile: 312-372-8691

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EXHIBIT A

US005444776A

United States Patent [19]

Sheets et al.

[11] Patent Number: 5,444,776

[45] Date of Patent: Aug. 22, 1995

[54] BRIDGE FOR A NETWORK INTERFACE UNIT

[75] Inventors: Laurence L. Sheets, Woodridge; Daniel C. Peterson, St. Charles, both of Ill.

[73] Assignee: Teltrend Inc., St. Charles, Ill.

[21] Appl. No.: 151,505

[22] Filed: Nov. 12, 1993

[51] Int. Cl.⁶ H04B 3/46

[52] U.S. Cl. 379/399; 379/5; 379/412; 370/85.6; 370/85.11

[58] Field of Search 379/399, 412, 5; 370/85.6, 85.11, 16, 60, 13

[56] References Cited

U.S. PATENT DOCUMENTS

3,568,100	3/1971	Tarbos	333/18
5,173,896	12/1992	Dariano	379/21
5,224,149	6/1993	Garcia	379/5

Primary Examiner—James L. Dwyer
Assistant Examiner—Jacques M. Saint-Surin
Attorney, Agent, or Firm—Banner & Allegretti, Ltd.

[57] ABSTRACT

A network interface unit interconnected between a network span and a customer premises. The network span includes network transmit lines and network receive lines. The network interface unit includes a passive resistance circuit in the receive direction path that allows monitoring of signals from a central office in the presence of open circuit reflection or noise from the customer premises.

18 Claims, 4 Drawing Sheets

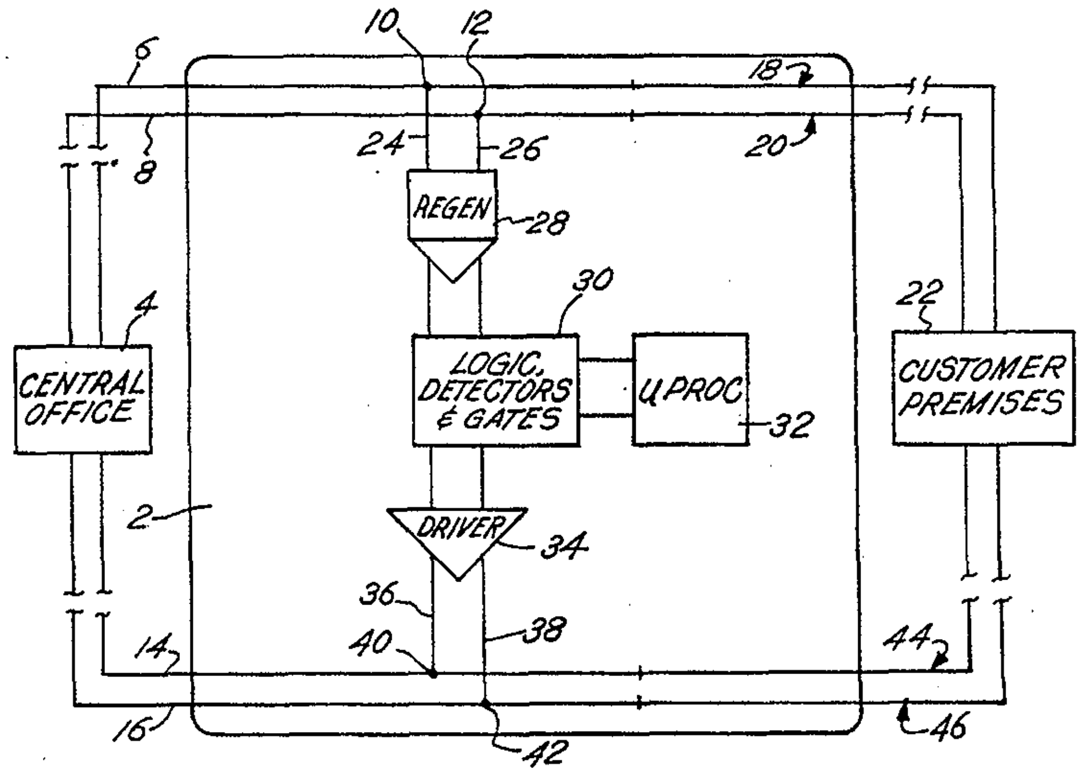
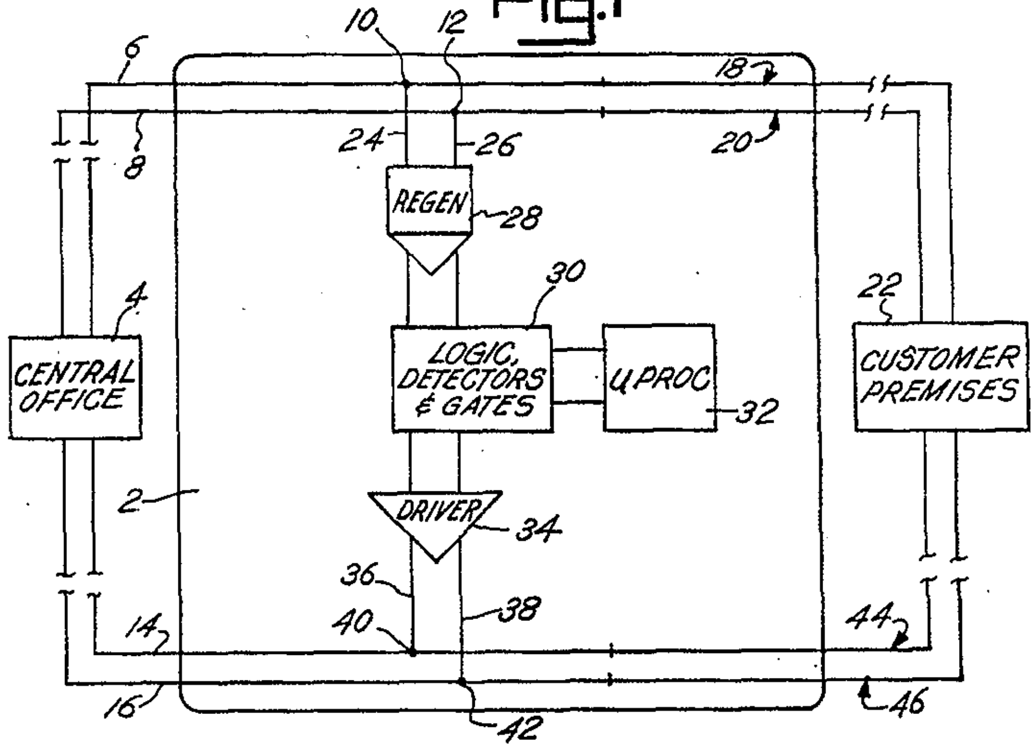
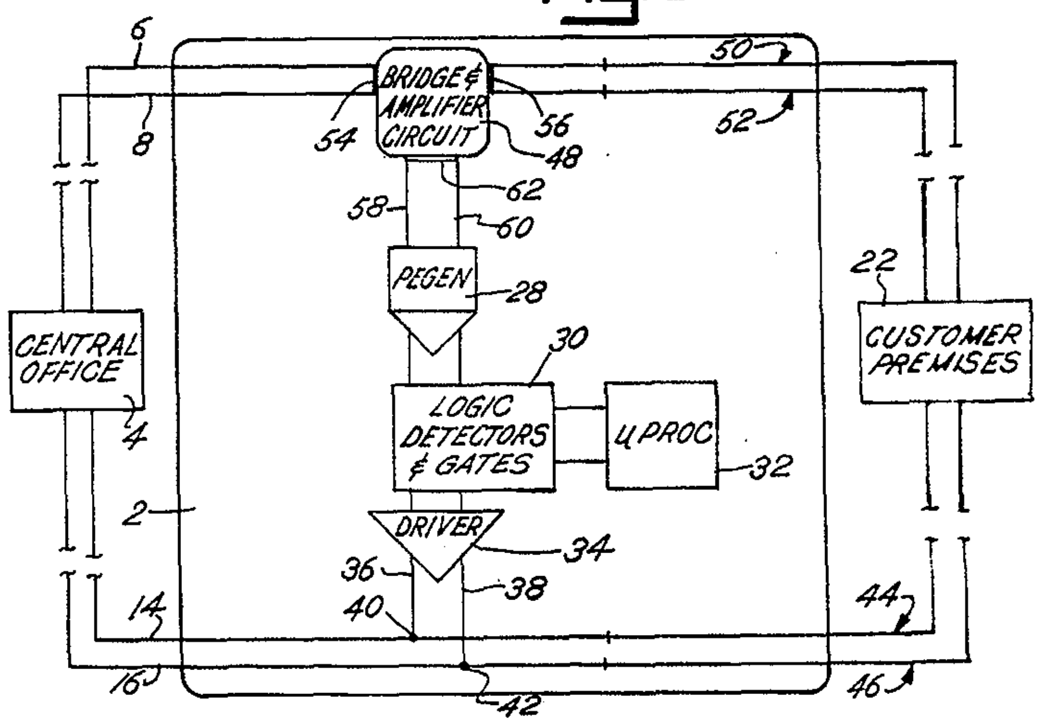


Fig. 1



CENTRAL OFFICE
REGEN
LOGIC, DETECTORS & GATES
µPROC
DRIVER
CUSTOMER PREMISES

Fig. 2



BRIDGE & AMPLIFIER CIRCUIT
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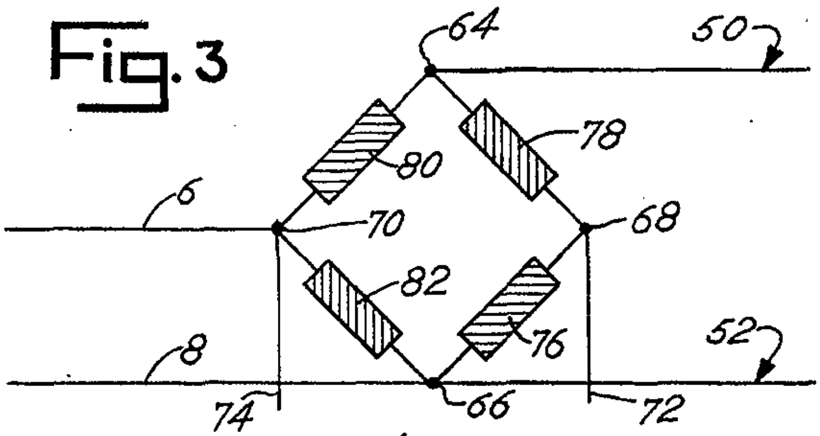
Fig. 3



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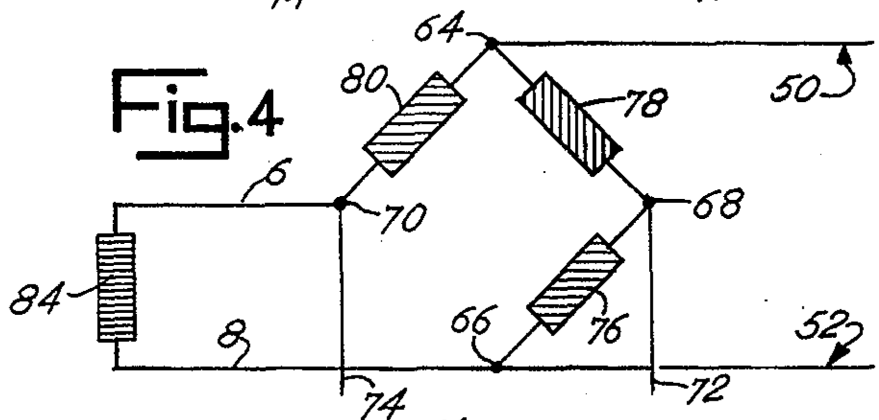
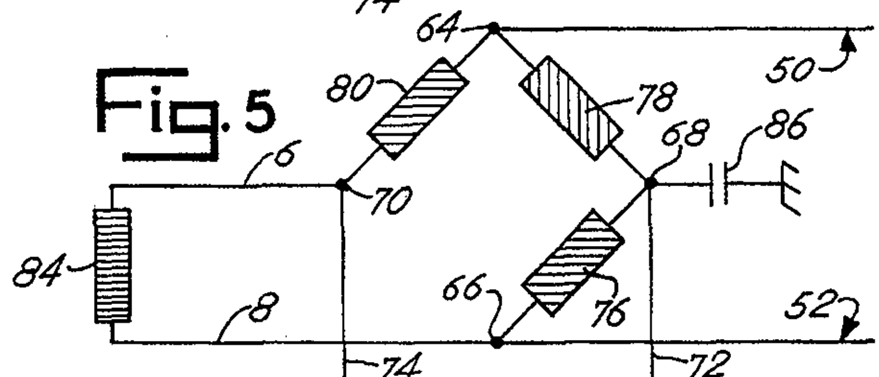


Fig. 5



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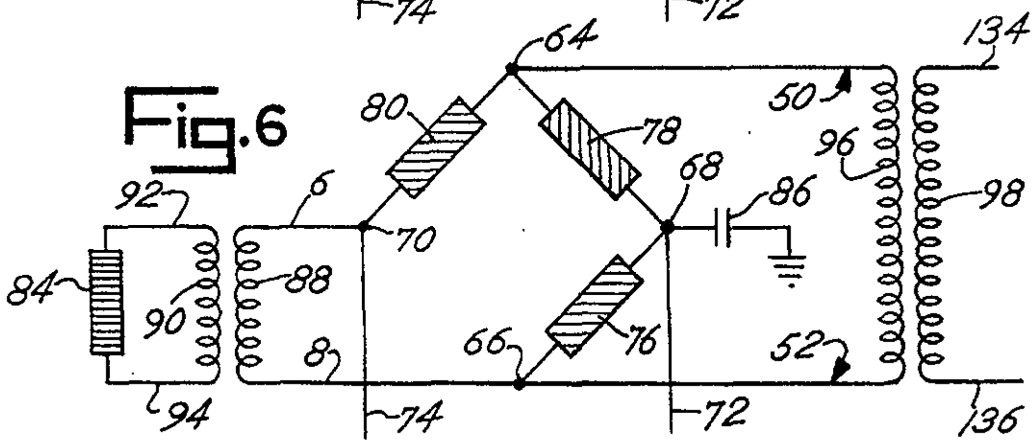

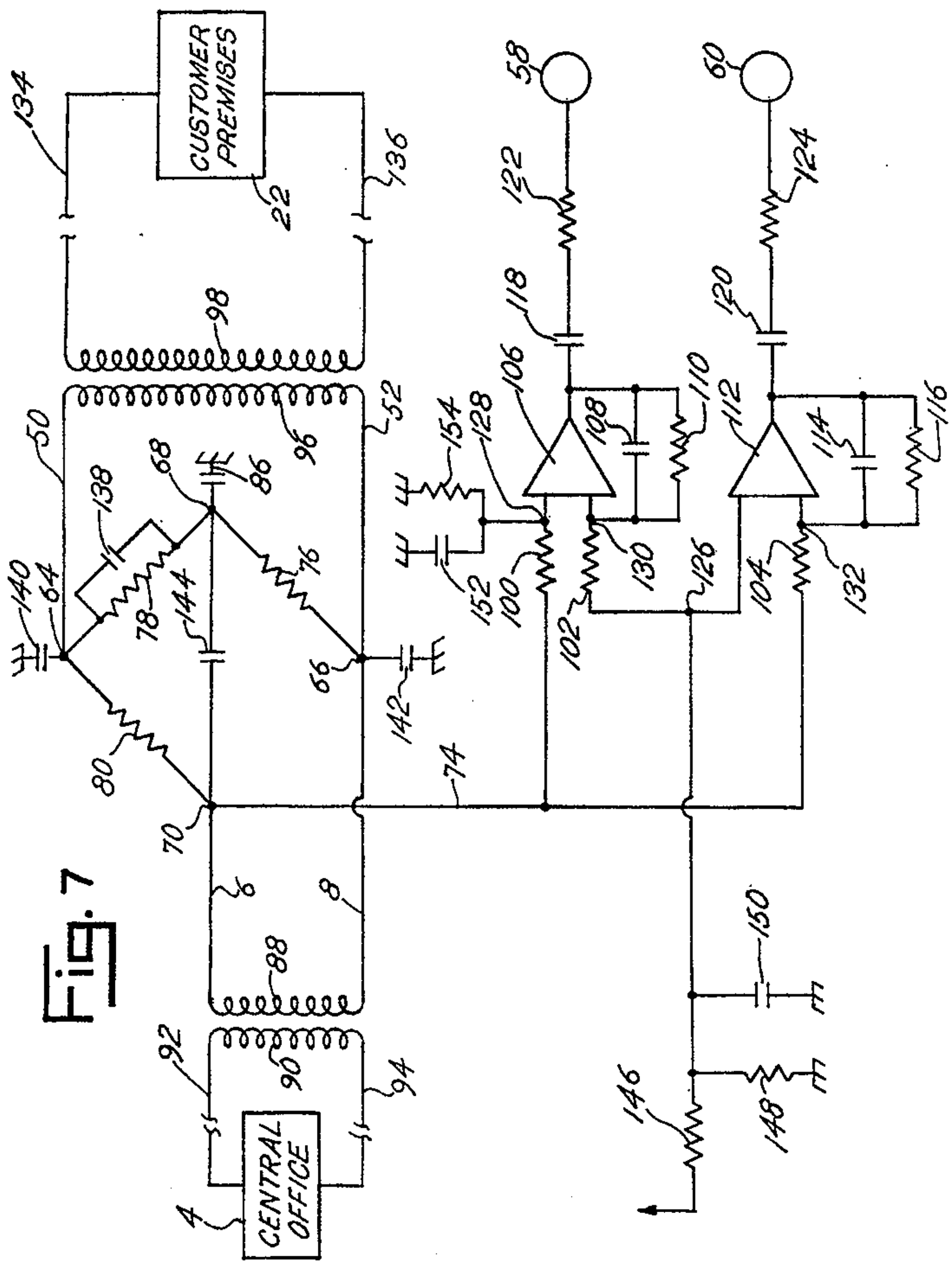
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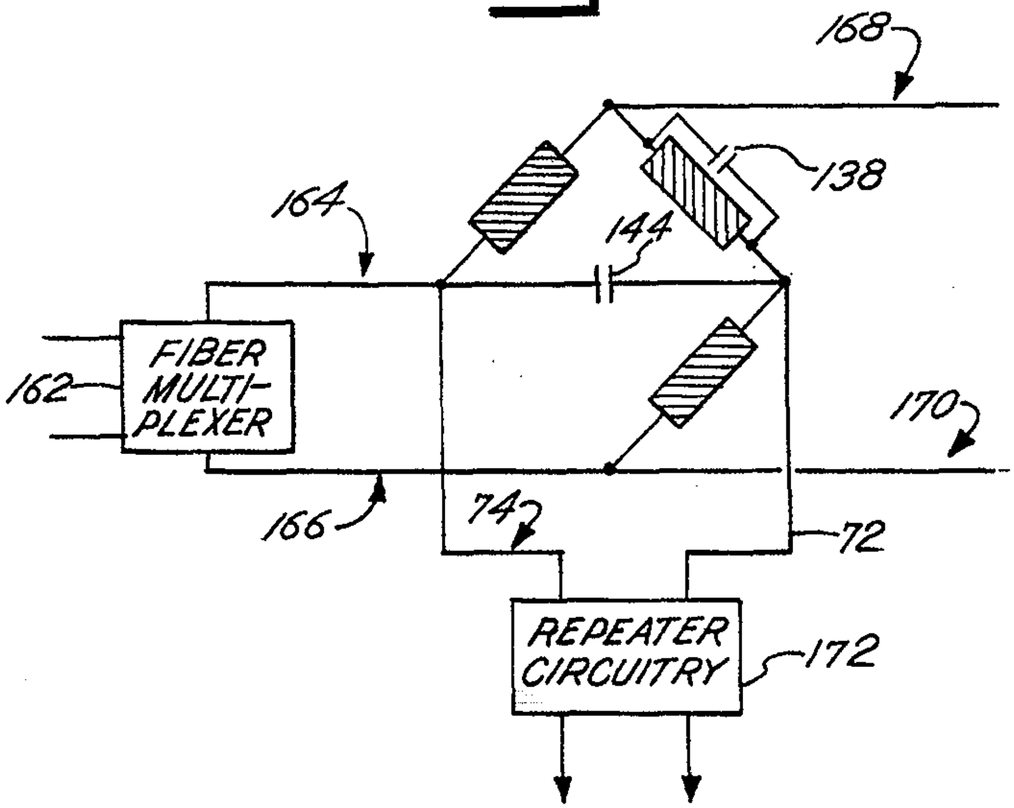
Fig. 7

Fig. 8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FIBER MULTI-PLEXER
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REPEATER CIRCUITRY
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BRIDGE FOR A NETWORK INTERFACE UNIT

BACKGROUND OF THE INVENTION

The present invention relates generally to interface units on digital transmission line systems and, more particularly, to a Network Interface Unit ("NIU") that may report its status to a remote facility. Thus, for example, the invention assists a telephone company technician in identifying, from a central office, the location of a break in a digital transmission line.

NIUs are typically located at the interface between a digital transmission line and a customer premises and usually serve as the demarcation between a telephone company line and a customer premises. In general operation, when an NIU receives a signal on the digital transmission line from the central office, the NIU, in turn, transmits that signal to equipment on the customer premises. Similarly, when the NIU receives a signal from the customer premises, the NIU transmits that signal to the central office on the digital transmission line.

The present invention may be used with digital transmission lines generally, including, for example, the Regional Bell Telephone Systems in the United States. As is discussed in Pesetski and Arnone U.S. patent application Ser. No. 07/943,859, filed Sep. 11, 1992, the Bell Telephone System has widely utilized time multiplexed pulse code modulation systems. Such systems have generally been designated as "T carriers." The first generation of multiplexers designed to feed the T1 system was the D1 channel bank. Channel banks have evolved through the D5 series. The "D" channel bank provides multiple DS-1 signals that are carried on the T1 systems. Each T1 system carries twenty-four two-way channels on two pairs of exchange grade cables. One pair of cables provides communication in each direction. The information on such a pulse code modulated system is transmitted in the form of bipolar or alternate mark inversion (AMI) pulses.

The data to be transmitted over the cables, such as speech, may be sampled at a rate of 8,000 Hertz, and the amplitude of each signal is measured. The amplitude of each sample is compared to a scale of discrete values and assigned a numeric value. Each discrete value is then encoded into a binary form. Representative binary pulses appear on the transmission lines.

As discussed in Sheets U.S. patent application Ser. No. 07/844,129 filed Mar. 2, 1992, the data, or "payload," signals on such transmission lines are typically sent differentially on a Tip-Ring pair. Payload signals are received by the telephone company central office and, generally, are transmitted, via cables, to a series of regenerative signal repeaters ("line repeater" or "signal repeater"). Such repeaters are spaced along the cables approximately every 6,000 feet. The first repeater receives the data from the central office, but, because of transmission line losses, noise, interference, and distortion, the signal will have degenerated. The repeater recognizes the presence or absence of a pulse at a particular point in time and, thereafter, if appropriate, regenerates, or "builds up," a clean, new pulse. A regenerative repeater is powered by the transmission cable itself to generate the new pulses. The new pulses are transmitted by the line repeater along more cable to either another line repeater or to an NIU.

As further explained in Sheets U.S. patent application Ser. No. 07/844,129 filed Mar. 2, 1992, some "intelligent" line repeaters also include a "dead loop" feature. In this mode, a break in the transmission line or a disconnection of the customer's equipment from the NIU causes the line repeater or the NIU to "dead loop," such that any signal transmitted from the central office is simply rerouted back to the central office. Accordingly, the central office is advised of the abnormality along the transmission cables. The "dead loop" condition may be released if, for example, the line is corrected or the customer's equipment is reconnected to the NIU.

As further noted in Sheets U.S. patent application Ser. No. 07/844,129 filed Mar. 2, 1992, NIUs commonly have the capability to identify errors in the data received over the cable and responsively provide a signal to the central office that the errors have occurred. Errors that can be detected by the NIU include, for example, errors in signaling, format, bipolar violations, out of frame data, or loss of signal, as well as the disconnection of equipment by the customer.

NIUs may include regeneration toward the customer premises. Similarly, the NIU may include regeneration in the opposite direction. The NIU may also include analog to digital circuitry to convert an analog signal from the customer premises to a digital signal for the central office.

For clarification and simplification of terminology, the pair of cables carrying signals from the central office to the NIU is designated as a "network receive" line, and the pair of cables transmitting data from the NIU is designated as the "network transmit" line. These designations are conventions in telecommunications defining directions relative to the end customer. Similarly, the two pairs of lines carrying signals to and from the NIU to the customer premises is designated as the "customer premises" lines.

NIUs may also include a "loopback" feature that allows the central office to ascertain whether or not a particular span of cable provides continuity along its entire length. For example, the central office may send, via the digital transmission lines, an activating signal, which does not interfere with normal transmission operations, that designates the NIU to "loop back" a signal to the central office. If no break is present on transmission lines, the NIU will receive the signal on the network receive line, and transmit a loopback signal to the central office on the network transmit line.

If, however, the digital transmission line has a break on either the network receive line, network transmit line, or both, then the central office will not receive a loopback signal in response to an activating signal. That is, if a break is present on the network receive line, the NIU will never receive an activating signal, or if a break is present on the transmit line, the central office will never receive a loopback signal on the network transmit line. Use of a loopback feature with repeaters is discussed in Garcia U.S. Pat. No. 5,224,149, issued Jun. 29, 1993.

In some instances, the activating signal for an NIU loopback becomes distorted, interrupted, or lost. In addition, false loopback signals may render the loopback procedure worthless for identifying the location of breaks in transmission lines.

These types of problems may occur because the loopback circuitry is coupled not only to the network receive lines, but also to the customer premises lines. Thus, a signal on the customer premises line may interfere with the loopback procedure. For example, a voltage on the customer premises lines may cause the NIU to transmit an unprompted loopback signal to the central office. Similarly, a voltage on the customer premises line may interfere with loopback circuitry and disrupt the loopback procedure.

One source of voltage on the customer premises line is open circuit reflection. An open circuit may appear on the customer premises line if, for example, lines are in the process of being installed in the customer premises, a customer disconnects equipment from the NIU, or there is a broken line within the customer premises. If the customer premises lines are an open circuit, open circuit reflection may occur, for example, if the length of the open circuit customer premises line is equal to one fourth of the wavelength of the signal from the central office. Similarly, where the length of the customer premises line is equal to the wavelength of the signal from the central office divided by four and multiplied by (2n+1); where n is a positive integer, open circuit reflection may cause a voltage null on the input of the sensing regenerator in the loopback circuitry.

One past method of addressing the problem of open circuit reflection has been to couple a high output impedance amplifier on the line from the NIU to the customer premises. This method is not desirable because it consumes current and is a power drain, and incurs the expense of a high output impedance amplifier in each NIU. Worse still, with the loss of local power, the output amplifier would not function and the transmission would be blocked in the receive direction.

Many of the concepts discussed in this background are further explained in Tarbos U.S. Pat. No. 3,568,100, issued Mar. 2, 1971, Garcia U.S. Pat. No. 5,224,149, issued Jun. 29, 1993, Pesetski and Arnone U.S. patent application Ser. No. 07/943,859, filed Sep. 11, 1992, and Sheets U.S. patent application Ser. No. 07/844,129, filed Mar. 2, 1992.

SUMMARY OF THE INVENTION

In a preferred embodiment of the invention, a network interface unit ("NIU") is interconnected between a network span and a customer premises. The network span comprises two pairs of digital transmission lines. One pair of lines carries signals from the central office to the NIU (receive direction), and one pair of lines carries signals from the NIU to the central office (transmit direction). Two pairs of lines carry signals to and from the NIU and the customer premises. The central office may test the continuity of the network span by transmitting an activating signal to the NIU, which the NIU loops back to the central office.

A passive resistance and amplification means is coupled between the two pairs of network lines and the monitoring so that a voltage on the customer premises lines will not falsely cause the NIU to transmit a signal to the central office, nor will a voltage on the customer premises lines interfere with an activating signal sent to the NIU from the central office.

Thus, an object of the present invention is an improved testing system for digital transmission lines. Another object of the present invention is a passive element for reducing problems caused by open circuit reflection on the customer premises lines. Yet another object of the present invention is a passive dement for reducing problems caused by a voltage on the customer premises lines. A further object of the present invention is a passive dement for reducing problems caused by voltages on the customer premises lines that does not consume excess power. Yet another object of the present invention is a passive element for reducing problems caused by voltages on the customer premises lines that has a fast response time and that will allow for normal transmission with the loss of local power.

Yet another object of the present invention is a testing system that is simpler, more reliable, and less expensive. These and other objects, features, and advantages of the present invention are discussed or are apparent in the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present invention are described herein with reference to the drawing wherein:

FIG. 1 is a block diagram of a prior art NIU;

FIG. 2 is a block diagram of an NIU incorporating a passive bridge and amplifier circuit according to the invention;

FIG. 3 is a schematic diagram of the passive bridge circuit;

FIG. 4 is a schematic diagram of a preferred embodiment of the passive bridge circuit;

FIG. 5 is a schematic diagram of the preferred embodiment of FIG. 4 with a capacitor for matching the impedance of the digital transmission line;

FIG. 6 is a schematic diagram of a passive bridge circuit and amplification means including a representation of a digital transmission line network and an output from the NIU to a customer premise; and

FIG. 7 is a schematic diagram of the passive bridge circuit and amplification means;

FIG. 8 is a schematic diagram of the passive bridge circuit in an office repeater.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a pictorial representation of a prior art network interface unit ("NIU") 2. A NIU 2 receives signals from a central office 4 on a network receive line 6 and a network receive line 8, which are coupled to the NIU 2 at a node 10 and a node 12, respectively. The NIU 2 transmits signals to the central office 4 on a network transmit line 14 and a network transmit line 16.

The designations of "network transmit" and "network receive" lines are, of course, arbitrary and labelled as shown in FIGS. 1-7 only for convenience. A "network transmit" line becomes a "network receive" line if the observer merely changes relative position.

A customer premises line 18 and a customer premises line 20 are also coupled to the node 10 and the node 12, respectively. In normal operation, the customer premises lines 18 and 20 are coupled to a customer premises 22. Also coupled to the nodes 10 and 12 are a regenerator input line 24 and a regenerator input line 26, respectively. The regenerator input lines 24 and 26 are coupled to a regenerator 28, the output of which is coupled to logic detectors and gates 30. The logic detectors and gates 30 are controlled by a microprocessor 32. The output of the logic detectors and gates 30 is amplified by a driver 34, and the output of the driver 34 is coupled to a driver output line 36 and a driver output line 38. The driver output lines 36 and 38 are coupled to the network transmit lines 14 and 16, at a node 40 and a node 42, respectively. A customer premises line 44 and a customer premises line 46 couple the customer premises 22 to the NIU 2 at the nodes 40 and 42, respectively.

In normal communication operation, the NIU 2 receives, on network receive lines 6 and 8, signals from the central office 4. These signals appear at the customer premises 22 on customer premises lines 18 and 20. Similarly, the customer premises 22 transmits signals to the NIU 2 on the customer premises lines 44 and 46. Customer premises lines 44 and 46 are coupled, at the nodes 40 and 42, to the network transmit lines 14 and 16, respectively, which provide a signal to the central office 4.

It should be noted that additional components or circuitry may appear between the nodes 10 and 12 and the customer premises 22, between the customer premises 22 and the nodes 40 and 42, between the nodes 40 and 42 and the central office 4, and between the central office 4 and the nodes 10 and 12. For example, regenerative signal repeaters (not pictured) may be spaced along network receive lines 6 and 8 between the central office 4 and the NIU 2. Accordingly, customer premises lines 18, 20, 44, and 46, network transmit lines 14 and 16, and network receive lines 6 and 8 are all depicted with a slash mark. This mark does not necessarily indicate a break in the line.

As was discussed in the background of the invention, when a test is conducted to determine the continuity of the transmission lines, the central office 4 transmits an activating signal to the NIU 2 on the network receive lines 6 and 8. The network receive lines 6 and 8 are coupled to the regenerator input lines 24 and 26, so the received signal is regenerated, processed and amplified by the regenerator 28, the logic detectors and gates 30 and the driver 34. The output lines of the driver 34, the driver output lines 36 and 38, are coupled to the network transmit lines 14 and 16 at the nodes 40 and 42, respectively. Thus, in response to an activating signal, the central office 4 receives a loopback signal on the network transmit lines 14 and 16.

If a break exists anywhere on the network receive lines 6 and 8 or the network transmit lines 14 and 16, the central office 4 will not receive a loopback response to its activating signal. Accordingly, a technician is able to determine the location of a break in the digital transmission lines by sending activating signals to the NIUs.

Referring to FIG. 2, an embodiment of the present invention is shown as the NIU 2. The NIU 2 receives signals from the central office 4 via the network receive lines 6 and 8. The network receive lines 6 and 8 are coupled to a bridge and amplifier circuit 48 at a Port A 54. Also coupled to the bridge and amplifier circuit 48 are a customer premises line 50 and a customer premises line 52. The customer premises lines 50 and 52 are coupled to the bridge and amplifier circuit 48 at a Port B 56. Again, additional components or circuitry may appear between the nodes 10 and 12 and the customer premises 22, therefore customer premises lines 50 and 52 are depicted with a slash.

An output segment line 58 and an output segment line 60 are also coupled to the bridge and amplifier circuit 48 at a Port C 62. The output segment lines 58 and 60 are also coupled to the regenerator 28. The regenerator 28 regenerates a signal present on the output segment lines 58 and 60, and the signal is further processed by the logic detectors and gates 30. The logic detectors and gates 30 are controlled by the microprocessor 32. The output of the logic detectors and gates 30 is amplified by the driver 34 and coupled to the driver output lines 36 and 38. The driver output lines 36 and 38 are coupled to the network transmit lines 14 and 16.

In a preferred embodiment, the output segment lines 58 and 60 (Port C) comprise an output segment. The term "output segment" refers to the output of the bridge and amplifier circuit, although the term "output" is arbitrary and is used for convenience. From the perspective of the regenerator 28, the output segment lines 58 and 60 are input lines.

FIG. 3 depicts schematically the passive bridge circuit portion of the bridge and amplifier circuit 48 in FIG. 2. The network receive lines 6 and 8 provide a signal from the central office 4 (not pictured in FIG. 3) to the passive bridge circuit at a node 70 and a node 66, respectively. The customer premises lines 50 and 52 are coupled to the bridge circuit at a node 64 and the node 66, respectively. Thus, the network receive line 8 is coupled to the customer premises line 52 at the node 66. Also coupled to the passive bridge circuit, at a node 68 and the node 70, are a passive bridge output line 72 and a passive bridge output line 74, respectively. Thus, the passive bridge output line 74 is coupled directly, at the node 70, to the network receive line 6.

It should be understood that in certain configurations, the passive bridge output lines 72 and 74 are coupled directly to the regenerator 28, shown in FIG. 2. In such a configuration, the passive bridge output lines 74 and 72 are the same lines as the output segment lines 58 and 60, respectively, depicted in FIG. 2. As depicted in FIG. 7, however, the passive bridge output line 74 may also feed an amplification circuit before being coupled to the regenerator 28. In this case, the signal present on the passive bridge output lines 72 and 74 is modified before the signal appears on the output segment lines 58 and 60. The amplification circuit is further discussed later in this description.

Referring again to FIG. 3, a resistor 76 is coupled between the node 66 and the node 68, a resistor 78 is coupled between the node 68 and the node 64, a resistor 80 is coupled between the node 64 and the node 70, and a resistor 82 is coupled between the node 70 and the node 66. In a preferred embodiment, the resistor 82 has a resistance of R ohms, the resistor 80 has a resistance of αR ohms, the resistor 78 has a resistance of $\alpha\beta$R ohms, and the resistor 76 has a resistance of αR ohms. Therefore, the resistance between the node 64 and the node 66, in other words the resistance on the customer premises lines, equals $R(1+\alpha)\beta/(1+\beta)$. If this resistance is set equal to the resistance between the node 70 and the node 66, in other words the network line resistance, then $\beta=1/\alpha$. Accordingly, the resistance of the resistor 76 is R/α, the resistance of the resistor 78 is R, the resistance of resistor 80 is $R\alpha$ and the resistance of resistor 82 is R. Therefore the resistance between the node 68 and the node 70 is $[R(1+\alpha)\ R(1+1/\alpha)]/[R(1+\alpha)+R(1+1/\alpha)]$, which equals R.

As previously discussed, the customer premises lines 50 and 52, in normal operation, are coupled to the customer premises 22 (not pictured in FIG. 3), and no voltage is generated by the customer premises 22 on the customer premises lines 50 and 52. Accordingly, in normal operation, no voltage is present between the node 64 and the node 66.

In normal communication operation, the NIU 2 receives, on network receive lines 6 and 8, signals from the central office 4. These signals appear at the nodes 70 and 66. The customer premises line 50 is coupled to the node 64 and the customer premises line 52 is coupled to the node 66. Thus, the voltage drop of the signal between the node 70 and the node 64, or across the resistor 80, depends on the resistance values of the resistor 80 and the resistance of the customer premises 22. The voltage at the node 64 is proportional to the voltage on the network receive lines 6 and 8. Not shown in FIG. 3 are customer premises lines 44 and 46 which couple the output of the customer premises 22 to the NIU 2 and the network transmit lines 14 and 16.

When a test is conducted to determine the continuity of the network receive lines 6 and 8 and the network transmit lines 14 and 16, the central office 4 transmits an activating signal to the NIU 2 on the network receive lines 6 and 8. The signal on the network receive line 6 appears on the passive bridge output line 74 because the two lines are coupled at the node 70. The voltage on the network receive lines 6 and 8 appears as the voltage between the node 70 and the node 66. The resistor 82 is interconnected between the node 70 and the node 66, therefore the voltage between the network receive lines 6 and 8 is across the resistor 82. Similarly, the voltage across the resistors 80, 78 and 76 is the voltage between the network receive lines 6 and 8. Accordingly, the voltage between the node 70 and the node 68 depends on the resistance of the resistors 80 and 78 and is a proportion of the voltage on the network receive lines 6 and 8.

As a result, the voltage swings on the passive bridge output line 74 are only a fraction of the voltage swings on the network receive lines 6 and 8. Using the resistance values discussed above, and assuming a voltage V on the network receive lines 6 and 8, the voltage drop along the resistor 80 is αV, the voltage drop along the resistor 78 is αV, the voltage drop along the resistor 76 is $(1-2\alpha)V$, and the voltage drop between the node 68 and the node 70 is 2α V. Thus, the voltage on the passive bridge output lines 72 and 74 is 2α V. Accordingly, the lower voltages allows for faster operation and also permits the use of less expensive components.

Although not shown in FIG. 3, the result of a signal on the passive bridge output lines 72 and 74 is a signal on the output segment line 58 and 60, and a signal on the network transmit lines 14 and 16. In sum, in response to an activating signal from the central office 4, the central office 4 receives a loopback signal on the network transmit lines 14 and 16. If a breaks exists anywhere on the network receive lines 6 and 8 or the network transmit lines 14 and 16, the central office 4 will not receive a response to its activating signal.

As discussed in the Background of the Invention, when the customer premises 22 is not connected to the customer premises lines 50 and 52, these lines are an open circuit. This situation may occur, for example, when there is no equipment attached to the customer premises lines 50 and 52. If the customer premises lines 50 and 52 have certain characteristics, an open circuit reflection may cause a voltage to be present on the customer premises lines 50 and 52. Thus, a voltage may exist between the node 64 and the node 66. Due to the relationship of resistance values of the resistors 78 and 80, discussed above, the voltage drop from the node 64 to the node 68 is the same as the voltage drop from the node 64 to the node 70. Thus, the voltage at the node 70 is the same as the voltage at the node 68, and, consequently, no signal is present on the passive bridge output lines 72 and 74. Thus, the open circuit reflection signal does not cause a signal to be sent to the central office 4, nor does open circuit reflection interfere with activating signals sent from the central office.

FIG. 4 depicts a preferred embodiment of the passive bridge circuit, similar to that shown in FIG. 3, where $\alpha << 1$. The resistance of the network is figuratively depicted as a resistor 84.

FIG. 5 depicts the passive bridge circuit similar to that shown in FIG. 4. A capacitor 86 is coupled to the node 68 of the passive bridge circuit. The capacitor 86 is to reduce circuit noise and is grounded.

FIG. 6 shows the passive bridge circuit similar to that shown in FIG. 5. The resistance of the network is figuratively shown as the resistor 84. Network receive lines 6 and 8 are shown coupled to an isolating transformer 88 that is matched to an isolating transformer 90. The isolating transformer 90 is coupled to a network receive line 92 and a network receive line 94. The customer premises lines 50 and 52 are shown coupled to an isolating transformer 96 that is matched to an isolating transformer 98. The isolating transformer 98 is coupled to a customer premises line 134 and a customer premises line 136.

A passive bridge and amplifier circuit is depicted in FIG. 7. The network receive lines 6 and 8 are shown coupled to the isolating transformer 88 that is matched to the isolating transformer 90. The isolating transformer 90 is coupled to the network receive line 92 and the network receive line 94, which are coupled to the central office 4. The customer premises lines 50 and 52 are shown coupled to the isolating transformer 96 that is matched to the isolating transformer 98. The isolating transformer 98 is coupled to a customer premises line 134 and a customer premises line 136 which are coupled to the customer premises 22. As discussed previously, additional components or circuitry may appear between the customer premises lines 134 and 136 and the customer premises 22, and between the central office 4 and the network receive lines 92 and 94. Accordingly, customer premises lines 134 and 136 and network receive lines 92 and 94 are depicted with a slash mark. This mark does not necessarily indicate a break in the line.

The network receive lines 6 and 8 provide a signal from the central office 4 to the passive bridge circuit at the node 70 and the node 66, respectively. The customer premises lines 50 and 52 are coupled to the bridge circuit at the node 64 and the node 66, respectively. Thus, the network receive line 8 is coupled to the customer premises line 52 at the node 66. Also coupled to the passive bridge circuit, at the node 70, is a passive bridge output line 74. Thus, the passive bridge output line 74 is coupled directly, at the node 70, to the network receive line 6.

The resistor 76 is coupled between the node 66 and the node 68, a resistor 78 is coupled between the node 68 and the node 64, and a resistor 80 is coupled between the node 64 and the node 70. A capacitor 138 improves the effectiveness of the circuit by matching the capacitance of the network. The capacitor 138 is connected in parallel with the resistor 78. A capacitor 140 is coupled to the node 64 to reduce circuit noise. The capacitor 140 is grounded. Similarly, a capacitor 142 is coupled to the node 66 to reduce circuit noise. The capacitor 142 is grounded. A capacitor 86 is also coupled to the node 68 of the passive bridge circuit. The capacitor 86 is to reduce circuit noise and is grounded. A capacitor 144 is coupled between the node 70 and the node 68.

The passive bridge output line 74 is generally coupled to amplification circuitry with the output segment lines 58 and 60. The amplification circuitry includes a resistor 146 coupled in parallel with a resistor 148 and also coupled in parallel with a capacitor **150** to a node **126**. The resistor **146** is also coupled to a reference voltage. A noninverting input to an amplifier **112** is also coupled to the node **126**. A resistor **102** is coupled between the node **126** and a node **130**. An inverting input to an amplifier **106** is also coupled to the node **130**. A capacitor **108** and a resistor **110** are coupled in parallel between the node **130** and the output of the amplifier **106**. The output of the amplifier **106** is coupled in series with the capacitor **118** and the resistor **122** to the output segment line **58**.

The passive bridge output line **74** is coupled in parallel to a resistor **100** and a resistor **104**. The resistor **100** is coupled to a node **128**. A capacitor **152** and a resistor **154** are coupled in parallel to the node **128**. A noninverting input of the amplifier **106** is also coupled to the node **128**. The resistor **104** is coupled to a node **132**. A inverting input to the amplifier **112** is coupled to the node **132**. A capacitor **114** and a resistor **116** are coupled in parallel between the node **132** and the output of the amplifier **112**. The output of the amplifier **112** is coupled in series to a capacitor **120** and a resistor **124** to the output segment line **60**. The resistor **148**, the resistor **154**, the capacitor **150**, and the capacitor **152** are coupled to ground. In sum, when a signal is present on the passive bridge output line **74**, an amplified signal appears on the output segment lines **58** and **60**.

In a preferred embodiment of the invention, the resistor **146** has a resistance of 4.99 k ohms, the resistor **148** has a resistance of 4.99 k ohms, the capacitor **150** has a capacitance of 1 microfarad, and the resistor **100** has a resistance of 100 ohms. Furthermore, in this preferred embodiment, the resistor **102** has a resistance of 100 ohms, the resistor **104** has a resistance of 100 ohms, the resistor **122** has a resistance of 1.2 k ohm, and the resistor **124** has a resistance of 1.2 k ohm. In addition, the capacitor **118** has a capacitance of 0.1 microfarads, the capacitor **120** has a capacitance of 0.1 microfarads, the capacitor **152** has a capacitance of 270 picofarads, and the resistor **154** has a resistance of 1.2 k ohms. Also, the resistor **80** has a resistance of 2 ohms, the resistor **78** has a resistance of 100 ohms, the resistor **76** has a resistance of 5.49 k ohms, and the capacitor **138** has a capacitance of 390 picofarads. Continuing, the capacitor **86** has a capacitance of 0.47 microfarads, the capacitor **144** has a capacitance of 470 picofarads, the capacitor **108** has a capacitance of 270 picofarads, and the resistor **110** has a resistance of 1.2 k ohms. Furthermore, the capacitor **114** has a capacitance of 270 picofarads, and the resistor **116** has a resistance of 1.2 k ohms. The resistor **146** is coupled to a 5 volt power supply.

The preceding demonstrates passive resistance means between a customer premises and a network span in a network interface unit. One embodiment of the invention includes a first and a second customer node, a first and a second network node, and a first and a second output node. In a preferred embodiment, the network span is comprised of network transmit lines and network receive lines and the network interface unit is a telephone network interface unit. Further, in a preferred embodiment, the network transmit lines the network receive lines are digital transmission lines.

It is to be understood, however, that alternative forms of the described embodiments are covered by the full scope of equivalents of the claimed invention. As one example only, the bridge circuit may also be used in an office repeater, as shown in FIG. **8**. The office repeater may be connected between a network receive line **168** and a network receive line **170** and a fiber multiplexer **162**. The fiber multiplexer **162** is coupled to the bridge circuit by a fiber multiplexer output line **164** and a fiber multiplexer output line **166**. The passive bridge output lines **72** and **74** may be coupled to repeater circuitry **172**. The passive bridge circuit will prevent reflection or other signals on the network receive lines **168** and **170** from interfering or distorting the signal on the passive bridge output lines **72** and **74**.

Generally, repeater circuitry such as the repeater circuitry **172** modifies and regenerates a signal that was transmitted along 2,500 to 5,000 feet of cable. Accordingly, the repeater circuitry **172** is designed to process a signal that is degraded due to cable loss. As shown in FIG. **8**, the bridge circuit may be configured to simulate such cable loss, and thus allow normal operation of the repeater circuitry. First, the bridge circuit attenuates the signal on the passive bridge output lines **72** and **74** relative to the fiber multiplexer output lines **164** and **166**.

In addition, the capacitor **138** and the capacitor **144** may be used to roll off pulses and further simulate cable loss characteristics. To particularly point out and distinctly claim the subjects regarded as the invention, the following claims conclude this specification.

We claim:

1. A network interface unit, interconnected between a network span and a premises segment, said network interface unit comprising:

an output segment;

first and second customer nodes, interconnected to said premises segment;

first and second output nodes, at least one of said output nodes being interconnected to said output segment;

a first passive impedance between said first output node and said first customer node;

a second passive impedance between said second output node and said second customer node; and

a third passive impedance between said first customer node and said second output node;

said first, second and third passive impedances cooperatively defining balancing means for dividing a reflected signal from said first and second customer nodes between said first and third passive resistances and substantially preventing said reflected signal from being provided to said first and second output nodes.

2. A network interface unit as claimed in claim **1** wherein said network span comprises digital receive lines.

3. A network interface as claimed in claim **2** wherein said network interface unit further includes capacitance means, in parallel with said third passive impedance, for substantially nullifying parasitic capacitance.

4. A network interface unit as claimed in claim **1** wherein said output segment is coupled to amplification means.

5. An office repeater, interconnected between digital network receive lines and a multiplexer, said office repeater comprising:

repeater circuitry;

first and second customer nodes, interconnected to said premises segment;

first and second output nodes, at least one of said output nodes being interconnected to said repeater circuitry;

a first passive impedance between said first output node and said first customer node;

a second passive impedance between said second output node and said second customer node; and

a third passive impedance between said first customer node and said second output node;

said first, second and third passive impedances cooperatively defining balancing means for dividing a reflected signal from said first and second customer nodes between said first and third passive impedances and substantially preventing said reflected signal from being provided to said first and second output nodes.

6. An office repeater as claimed in claim 5 wherein said office repeater includes capacitance means, in parallel with said third passive impedance, for simulating cable loss characteristics.

7. An office repeater as claimed in claim 5 wherein said multiplexer is a fiber multiplexer.

8. A network interface unit as claimed in claim 2 wherein said network receive span substantially presents a resistance of R ohms to said network interface unit and wherein said first impedance has a value of approximately αR ohms, said second impedance has a value of approximately βR ohms, and said third impedance has a value of approximately αβR ohms, where α and β are constants.

9. A network interface unit as claimed in claim 8 wherein R defines a nominal value of approximately 100 ohms and wherein α has a value of approximately 1/β.

10. A network interface unit as claimed in claim 5 wherein said network receive lines substantially present a resistance of R ohms to said office repeater and wherein said first impedance has a value of approximately αR ohms, said second impedance has a value of approximately βR ohms, and said third impedance has a value of approximately αβR ohms, where α and β are constants.

11. A network interface unit as claimed in claim 10 wherein R defines a nominal value of approximately 100 ohms and wherein α has a value of approximately 1/β.

12. A network interface unit coupled to a network receive span and a customer premises receive span, said network interface unit comprising:

logic circuitry for analysis of a loopback signal;

a first port coupled to said network receive span;

a second port coupled to said customer premises receive span;

a third port coupled to said logic circuitry; and

bridge circuit means for providing, in response to a first signal on said first port, related signals to said second and third ports and for dividing a second signal from said second port among said resistance devices, whereby said second signal is not transmitted to said third port and said logic circuitry, said bridge circuit means including

a first passive impedance coupling said first and second ports,

a second passive impedance coupling said first and third ports, and

a third passive impedance coupling said second and third ports.

13. A network interface unit as claimed in claim 12 wherein said network receive span comprises digital network receive lines.

14. A network interface unit as claimed in claim 13 wherein said network interface unit further includes balancing capacitance matching means, in parallel with said third passive impedance, for substantially nullifying parasitic capacitance.

15. A network interface unit as claimed in claim 13 wherein said first, second, and third impedances are, respectively, first, second, and third resistors.

16. A network interface unit as claimed in claim 15 wherein said network receive span substantially presents a resistance of R ohms to said network interface unit and wherein said first impedance has a value of approximately αR ohms, said second impedance has a value of approximately βR ohms, and said third impedance has a value of approximately αβR ohms, where α and β are constants.

17. A network interface unit as claimed in claim 16 wherein R defines a nominal value of approximately 100 ohms and wherein α has a value of approximately 1/β.

18. A network interface unit, coupled to first and second network receive lines and first and second customer premises receive lines, said network receive lines defining a network resistance, said network interface unit comprising:

a repeater having first and second repeater lines;

first, second and third resistors;

first and second output nodes, said first output node defining a first network receive node, said first output node being coupled to said first network receive line, said second repeater line, and said first resistor, said second output node being coupled to said first repeater line and said second and third resistors;

first and second customer nodes, said second customer node defining a second network receive node, said first customer node being coupled to said first customer premises receive line and said first and third resistors, said second customer node being coupled to said second customer premises receive line and said second resistor;

said bridge circuit, in response to a first voltage between said first and second network nodes, producing related voltages between said first and second customer nodes and between said first and second output nodes, and said bridge circuit, in response to a second voltage between said first and second customer nodes, balancing said second voltage between (1) said first resistor and said network resistance and (2) said second and third resistors to apply substantially equal portions of said second voltage at said first and second output nodes;

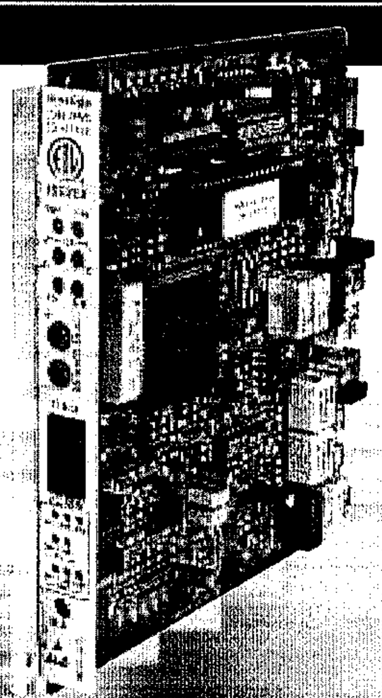
said first and second network receive nodes presenting to said network interface unit a nominal resistance between them of approximately 100 ohms, said first resistor having a value of approximately α100 ohms, said second resistor having a value of approximately β100 ohms, and said third resistor having a value of approximately 100 ohms, where α and β are constants and α is substantially smaller than β.

* * * * *

EXHIBIT B

Model 520-15SW Issue 1

DS1 Digital Network Interface Unit



Features

- "SLIM Mechanics" one half width Type-400 mechanics
- Powered from 60mA span current or locally powered from ±22Vdc to 56Vdc or 24Vac external source
- Inband and manual loopback activation and deactivation
- Front Panel LEDs for: Power, LPBK, LEC LOS, CI LOS, ESF, ALARM, during CPE LOS unit provides AIS or LPBK, RCV LBO 0dB or 7.5dB and XMT LBO 0dB/7.5dB/15dB
- Local Provisioning of CI LOS Indication of AIS or Automatic LPBK and REGEN
- Local Provisioning of RCV and XMT LBO and REGEN LBO
- Compatible with AMI and B8ZS line formats
- Temperature Hardened for indoor or outdoor applications (-40°C to + 65°C)
- Complies with Bellcore GR-1089 Issue 1 for short circuit, lightning surge and power cross protection
- Pin-type test jacks for measuring span current
- Bantam jack monitor access from the LEC and CI

Application

The Model 520-15SW, terminates DS1 High Capacity Digital Services at the customer premises. The 520-15SW is located on the network side of the point of demarcation between the Local Exchange Carrier (LEC) and the Customer Installation (CI). The primary function of the 520-15SW is signal loopback. Signal loopback enhances carrier maintenance operations by allowing the LEC to remotely sectionalize problems resulting in improved customer service. The 520-15SW is specifically designed for indoor or outdoor environment applications.

HyperEdge

www.hyperedge.com

EXHIBIT

tabbies

B

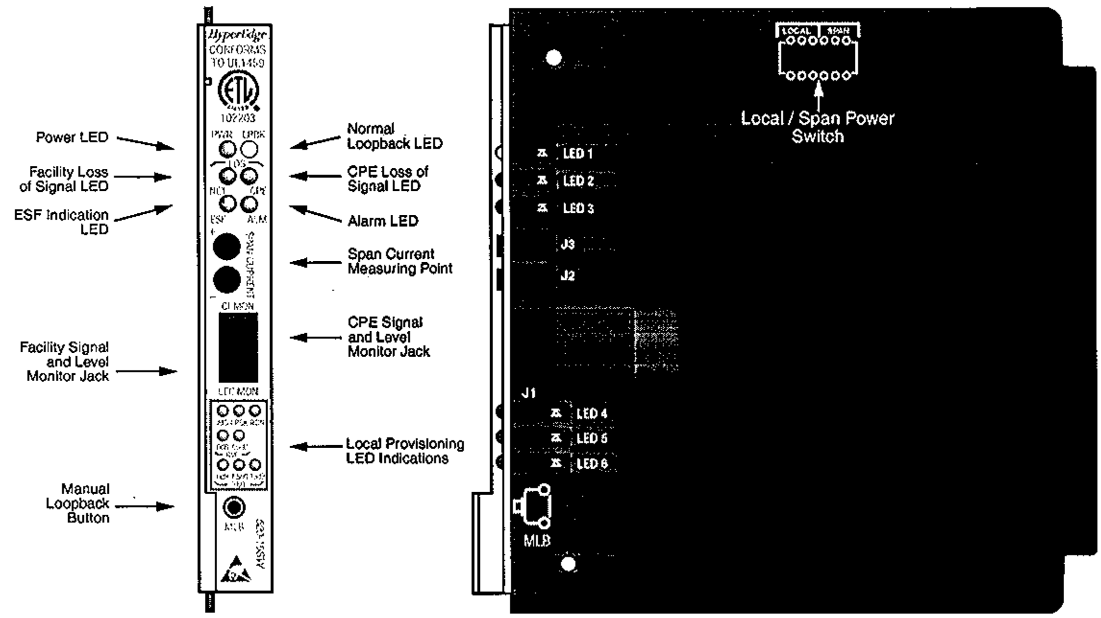
Specifications

DS1 Digital Network Interface Unit

Ordering Information

Specify HyperEdge Model Number:

520-15SW DS1 Network Interface Unit



Specifications

Line Rate: 1.544Mb/s

Insertion Loss: 1.0dB max at 772Khz

Line Impedance: 100 ohms (±20%) @ 772Khz

Loop-Up Code:
Inband (unframed or SF) 11000 (>5 sec.)
ESF-DL "0001 0010 1111 1111" >16 ms

Loop-Down Code:
Inband (unframed or SF) 11100 (>5 sec.)
ESF-DL "0010 0100 1111 1111" >16ms

Loopback Timeout:
120-minute automatic timeout

Manual Loopback Activation:
Press MLB switch (1 sec., then release); front panel LPBK LED lights steady

Manual Loopback Deactivation:
Press MLB second time or by sending loop-down code

Loopback Regeneration: 0 to 30dB line loss @ 772Khz

AIS Upon CI LOS: Set via MLB button during local provisioning

LPBK On CI LOS: Set via MLB button during local provisioning

RCV LBO: 0dB or 7.5dB

XMT LBO: 0dB, 7.5dB or 15dB

Power: Span Power at 57 to 63ma or local power at ± 22Vdc to 56Vdc or 24Vac

DC Voltage Drop (Span Powered):
Less than 15VDC at 60mA

Maximum Detect Error Rate: $<10^{-3}$

Operating Environment: Temperature -40° to 150°F (-40° to 65°C); Humidity 0 to 95% – No condensation

Dimensions: Height 5.6"; Width 0.7"; Depth 5.9"

Weight: Approximately 12 oz.

HyperEdge
333 Pierce Road
Suite 200
Itasca, IL 60143-3147

866-HYPEREDGE
800-377-8766 *Customer Service*
630-761-1890 *Fax*

www.hyperedge.com

EXHIBIT C

WESTELL
We Listen • We Understand • We Deliver

Via fax and Certified Mail

Dwight Swartwood
President & CEO
HyperEdge
940 Kingsland Drive
Batavia, Illinois 60510

February 1, 2002

Dear Mr. Swartwood:

I am General Counsel for Westell Technologies, Inc.("Westell"). It has come to my attention that HyperEdge Corporation is infringing U.S. Patent No. 5,444,776, which is assigned to Westell, at least with respect to your Troncom design. The '776 patent of August 22, 1995, originally assigned to Teltrend Inc. (a company that Westell later acquired in 1990), relates to a "Bridge for a Network Interface Unit." A copy of the '776 patent is enclosed for your convenience.

As you know, Westell is a world leader in developing intellectual property relating to infrastructure for advanced data, video, and voice networks. As such, Westell must do what is necessary to defend, protect, and enforce its intellectual property. In this case, that means that Westell must demand that HyperEdge immediately cease and desist the manufacture, use, development, sale, importation, and/or marketing of any device that infringes the '776 patent. Westell must further demand that you provide to us by **February 15, 2002** a sworn statement that HyperEdge is no longer making, using, developing, selling, importing, and/or marketing any device that infringes the '776 patent. That sworn statement should include an enumeration of the steps that HyperEdge has taken and is taking to ensure that it will never again infringe the '776 patent. Finally, after you have had a chance to review the '776 patent and HyperEdge's records, please contact me to discuss a procedure for accounting for the harm done to Westell by HyperEdge's infringement up to this point.

We hope that we can avoid the expense and burden of litigation through an informal resolution of this matter. However, please be aware that Westell is prepared to avail itself of all avenues necessary to protect the fruits of its research and development labors, up to and including patent infringement litigation in the United States District Court. Should you have any questions, please contact me.

Very truly yours,

Frances S. Cook

Frances S. Cook
General Counsel

FEB 5 2002

Enclosure

cc: Bradley J. Hulbert, Esq.

EXHIBIT
C

750 N. Commons Drive • Aurora, Illinois 60504
(630) 898-2500 • (800) 323-6883 • (630) 375-4940 Fax

EXHIBIT D

PATULA & ASSOCIATES
ATTORNEYS & COUNSELORS AT LAW
A PROFESSIONAL CORPORATION

116 South Michigan Avenue
Chicago IL, U.S.A. 60603
E-Mail: patula@worldnet.att.net
Phone: (312) 201-8220
Fax: (312) 372-8681

February 21, 2002

Ms. Frances S. Cook
General Counsel
Westell
750 N. Commons Drive
Aurora, Illinois 60504

Re: Westell v. HyperEdge Corp.
Allegation of Infringement of U.S. Patent 5,444,776
Our File No.: 5291/55469

Dear Ms. Cook:

As you know, we are intellectual property counsel for HyperEdge. Your undated letter received February 4, 2002 has been referred to us for response.

Although your letter does not provide much in the way of specifics, we have conducted a thorough investigation and have determined that none of HyperEdge's/Troncom's products infringe, or have ever infringed, the claims of U.S. Patent No. 5,444,776.

We will now consider this matter closed. If you have any further comments, please do not hesitate to contact us.

With sincere regards,

PATULA & ASSOCIATES, P.C.

Timothy T. Patula

cc: HyperEdge Corp.

72C29

EXHIBIT
D

EXHIBIT E

WESTELL

Via Overnight Mail

April 17, 2002

Timothy T. Patula
Patula and Associates
116 S. Michigan Avenue
Chicago, Il 60603

Re: Westell, Inc. v. HyperEdge Corporation
U. S. Patent No. 5,444,776

Dear Mr. Patula:

We received your letter of February 21, 2002 wherein you state that your client, HyperEdge, had investigated and determined that none of its products infringe or have ever infringed the claims of U. S. Patent No. 5,444,776. In light of your denials, we further studied the evidence and ran careful tests. We now conclude that your denials of infringement are meritless, and we view your conclusory claims of lack of infringement to be an attempt to throw Westell off of a well-founded course of conduct. Our conclusion is especially forceful with respect to HyperEdge's 520-15SW network interface unit. If, after a careful consideration of the evidence HyperEdge believes that we are incorrect, please provide us a full analysis of HyperEdge's factual analysis and legal reasoning immediately.

We take this matter very seriously. With this in mind, attached please find a copy of the Complaint that we intend to file to preserve and enforce Westell's patent rights. Although this is an unfortunate development, it has been caused by HyperEdge's intransigence in denying infringement despite what appears to be direct copying of the '776 patent. We would instead prefer to resolve this matter amicably.

In light of our preference for amicable resolution of this infringement and our belief that it is in everyone's best interest to avoid the costs and difficulties of litigation, we are willing to discuss the possibility of settlement with HyperEdge. We believe that a reasonable royalty for HyperEdge's past infringement could not be less than $ 6 million. For a prospective license, Westell would require an up-front payment of $1 million and a $5.00 royalty on each infringing item sold.

Please contact me to discuss this matter no later than April 26, 2002.

Very truly yours,

Frances S. Cook
Frances S. Cook
General Counsel

750 NORTH COMMONS DRIVE AURORA, IL 60504
(630) 898-2500 (800) 323-6883
WWW.WESTELL.COM

EXHIBIT
E

EXHIBIT F

PATULA & ASSOCIATES

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May 10, 2002

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Facsimile Transmission
To: Ms. Frances S. Cook, Esq.
From: Timothy T. Patula, Esq.
Fax No.: 630-375-4940
Pages: 13

Re: **Allegation of Infringement of U.S. Patent 5,444,776**
Our File No.: 5291/55469

Dear Fran:

This letter is in response to your letter of April 17, 2002, and our subsequent teleconferences.

In view of your letter, we have again conducted a thorough infringement investigation, specifically with respect to HyperEdge's discontinued 520-15SW network interface unit, which was sold in minimal quantities over a two year period from 1999. Please be advised that since 2001, HyperEdge has been shipping the 520-15SW, Issue 2, which does not use a bridge circuit having three passive impedances, and as such, clearly does not infringe Westell's patent. Nonetheless, we have again determined that none of HyperEdge's/Troncom's products, including the discontinued 520-15SW network interface unit, infringe or have ever infringed the claims of U.S. Patent No. 5,444,776.

Specifically, HyperEdge's products, including the discontinued 520-15SW network interface unit, do not include, *inter alia*, "*balancing means for dividing a reflected signal from said first and second customer nodes between said first and third passive resistances and substantially preventing said reflected signal from being provided to said first and second output nodes,*" as required by independent Claim 1 (and independent Claim 5 directed to an office repeater).

Similarly, HyperEdge's products do not include, *inter alia*, a bridge circuit means for "*dividing a second signal from said second port among said resistance devices,*" as required by independent Claim 12; nor a bridge circuit "*balancing said second voltage between (1) said first resistor and said network resistance and (2) said second and third resistors to apply substantially equal*

EXHIBIT
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portions of said second voltage at said first and second output nodes," as required by independent Claim 18. As you may know, since the independent claims are not infringed, the dependent claims cannot be infringed. Thus, there is no infringement of the claims of Westell's patent.

Further, we are highly confident that Westell's patent is invalid as being anticipated by, and/or obvious to one of ordinary skill in the art in view of well known prior art. Long used college engineering textbooks describe numerous "Bridge" circuits of the type claimed in Westell's patent, including one commonly known as a Return Loss Bridge. The Return Loss Bridge and two other "Bridge" circuits dating back to at least the early 1980's are specifically described on pages 151-159 in W.H. Hayward's 1982 textbook entitled "*Introduction to Radio Frequency Design*" (attached hereto). In fact, some of HyperEdge's design engineers worked on similar bridging techniques at Rockwell/Wescom more than one year before the application for Westell's patent was filed.

Please be assured that our client also takes this matter very seriously, and appreciates your offer for a license. However, since non-infringement, as well as invalidity, is clear, our client must decline your offer. Should you believe you have additional information indicating otherwise, such as the results of your "careful tests," we would be happy to review the same and indicate where your belief is mistaken.

Finally, while an amicable resolution to this matter is preferred, please be advised that our client will vigorously defend itself from any frivolous infringement claims, and will seek treble damages and all attorney's fees and costs associated with Westell knowingly attempting to enforce an invalid patent against products that are known not to infringe. Our client will further seek any and all damages, attorney's fees and costs for Westell's patent misuse, inequitable conduct, fraud, intentional interference with business, and the like. Any such lawsuit would amount to nothing more than harassment by Westell of a much smaller competitor, and HyperEdge's customers would surely be sympathetic.

Again, we will now consider this matter closed. If you have any further comments, please do not hesitate to contact us.

With sincere regards,

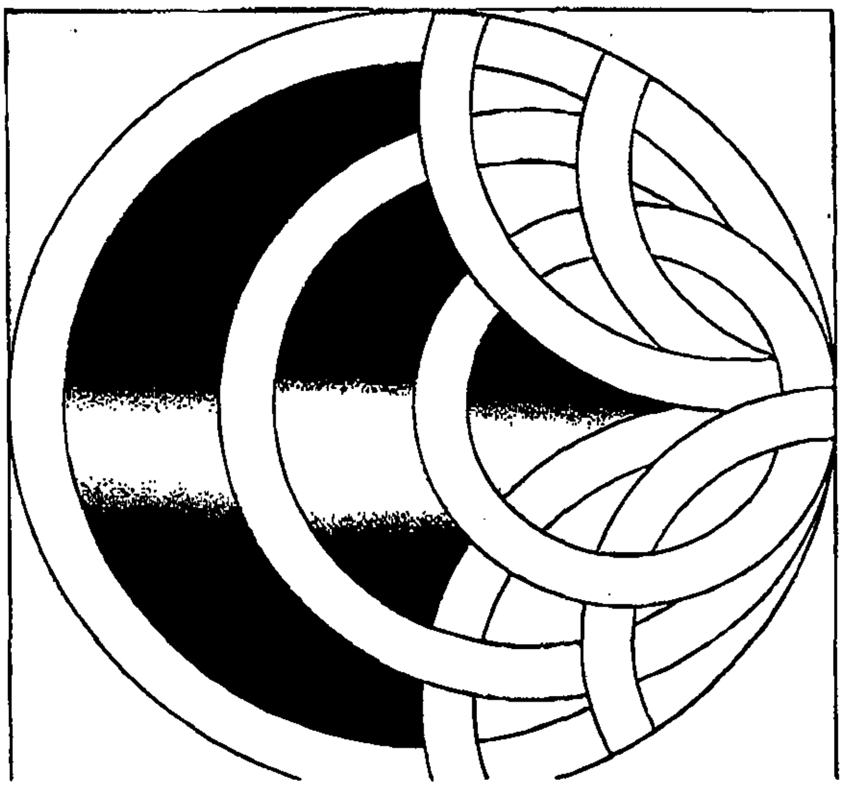
PATULA & ASSOCIATES, P.C.

Timothy T. Patula

Enclosure
cc: HyperEdge Corp.
85C30

Introduction to Radio Frequency Design

W. H. Hayward



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There are numerous other configurations and applications for the broadband transmission line transformer. The reader is referred to the literature (9).

Construction of transmission line transformers is not generally difficult. The length of the line should be somewhere around an eighth wavelength at the highest frequency of operation, although some transformers work well with a shorter line. The characteristic impedance of the line is critical. Low impedance lines are required to transform from 50 Ω down to lower impedances. Coaxial cables in miniature sizes are available with Z_0 as low as 25 Ω. A normal twisted pair of plastic covered wire with only a few twists per centimeter will have an impedance near 100 Ω. A tightly twisted pair of enamel covered wires will have a characteristic impedance close to 50 Ω. Lower impedances are synthesized by winding two or more lines on a core. The windings are then paralleled at the ends. The use of wire with different insulation colors is a great advantage during the winding process.

Low frequency performance of transmission line transformers is almost completely dominated by conventional transformer action. Hence, the core material becomes critical. It should have high permeability to ensure adequate primary inductance. Care must be taken to select a core that is not excessively lossy. In addition, stray inductance in the interconnection of the windings should be avoided, for it can detract from the high frequency performance.

4.6 TRANSMISSION LINE MEASUREMENTS

Transmission line concepts have been introduced. The voltage and current in the line obey the usual physical laws and may be analyzed using traditional methods. However, we found that energy propagates along a transmission line in the form of waves. A method of analysis based upon these waves, the reflection coefficient, was introduced as an analytical tool. Further study led to the Smith chart.

The utility of the reflection coefficient concept comes from the interaction of two waves. One is an incident wave while the other is the result of a reflection. The ideal measurement would be one which separates the incident and reflected waves. The tools to do this are presented in this section.

Probably the most generally useful means for measuring reflection coefficients is the return loss bridge, shown schematically in Fig. 4.32. Much of its utility lies in its simplicity. Additionally it will be useful for other applications. The bridge consists of three resistors, a pseudobalun transformer with a R_0 characteristic impedance, a suitable enclosure and three coaxial connectors. All three resistors are identical with a value R_0, the characteristic impedance of the transmission line for which the bridge is designed.

The transformer serves two purposes. It allows a difference in voltage between points A and B to appear unbalanced at the detector port. The transformer also causes the detector impedance to appear across the bridge between points A and B. The bridge will have a loss of 6 dB when terminated in a load of R_0. There is then no voltage difference between the detector points, A and B. Hence, no power is

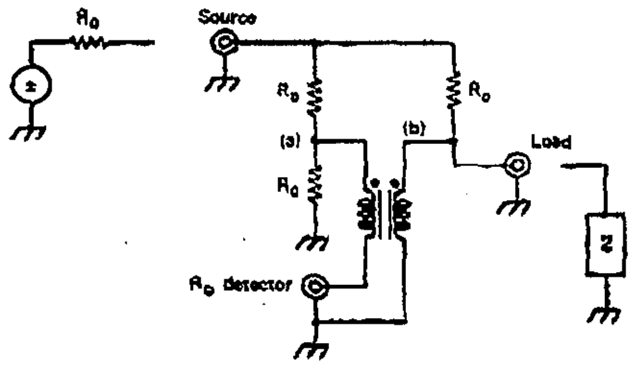

Figure 4.32 A return loss bridge, a. known as a 6-dB hybrid combiner. Th circuit is extremely useful for the measurement of complex impedances.

delivered to the detector. The power delivered by the generator is split into four equal resistors, one of them being the load, accounting for the 6-dB insertion loss. The impedance presented to the genertor is also R_0.

The bridge action is analyzed in Fig. 4.33. The circuit has been normalized to a characteristic impedance of 1 Ω. The open circuited generator voltage is set at 8 V. Arrows in the schematic show the assumed current direction. Three unknown voltages, corresponding to a three node circuit, are shown. E is the voltage applied to the bridge while V_1 and V_2 are the potentials at the detector port. At E, the nodal equation is

$$8 - E = E - V_1 + E - V_2 \tag{4.6-1}$$

The nodal equation at the left detector point is

$$E - V_1 = V_1 + V_1 - V_2 \tag{4.6-2}$$

while at the unknown load, the sum of the currents is

$$V_1 - V_2 + E - V_2 = V_2 y \tag{4.6-3}$$

where y is the normalized, unknown admittance defined by the load.

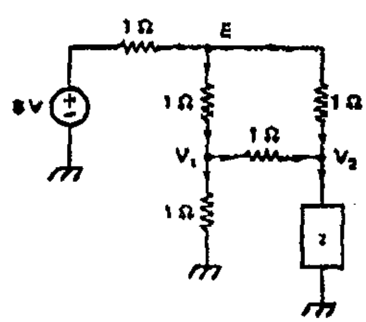

Figure 4.33 The circuit used for analysis of the return loss bridge where the characteristic resistance of the bridge is 1 Ω.

Simultaneous solution of Eqs. 4.6-1 through 4.6-3 yields the three unknown voltages

$$V_2 = \frac{4}{y+1}$$
$$V_1 = \frac{y+3}{y+1} \qquad (4.6\text{-}4)$$
$$E = \frac{3y+5}{y+1}$$

The voltage difference across the detector is calculated, and z, the normalized impedance, is factored into the result in place of y, yielding

$$V_2 - V_1 = \frac{1-y}{1+y} = \frac{z-1}{z+1} \qquad (4.6\text{-}5)$$

This is exactly the definition of the reflection coefficient. Hence, the voltage at the detector, a vector quantity, has a magnitude equal to the reflection coefficient magnitude and a phase angle with respect to the source phase equal to that of the reflection coefficient.

An 8-V source is an impractical restriction. A generator of arbitrary strength is attached and the load port is either open circuited or shorted. The power in the detector is noted. Then the unknown load is attached. The power at the detector will decrease. The magnitude of the decrease is the return loss in dB. Although not immediately obvious, the characteristic impedance of the source must be that of the bridge for accurate results. The same power will not be seen in the detector when going from an open to a short circuit at the load port if there is a generator mismatch.

The phase angle of the detector voltage is usually measured with a vector voltmeter such as the Hewlett-Packard HP-8407A. It may also be done with an oscilloscope triggered from the source generator, although accuracy is poor.

Other methods may be used for phase determination. The bridge is first used as described to measure the return loss (magnitude of Γ). Then, a sample of the generator is attenuated until it has the same amplitude as the signal at the detector port. The resulting two signals are algebraically added or subtracted in a resistive network. The result, still a scalar measurement, is combined with the value of attenuation used in the generator sampling line to infer the phase angle. Phasor analysis methods are used. The writer first learned of this method from Dr. R. D. Middlebrook (10).

Another application of the return loss bridge (RLB) is as a 6-dB hybrid combiner. This device is used to add two signals. The necessary characteristics are that system impedances be maintained and that the two sources be isolated. Operation of the

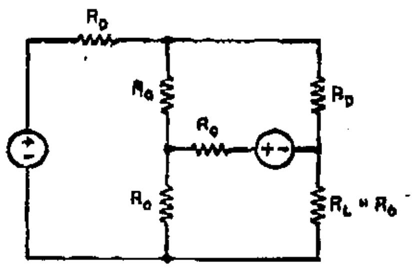

Figure 4.34 Use of a return loss bridge to combine signals from two sources while maintaining isolation.

RLB as a combiner is shown in Fig. 4.34 where the earlier circuit is drawn without the transformer and without any ground. The available energy from each generator appears at the load, but attenuated by 6 dB. The bridge action causes the energy from one generator to be cancelled at the other. A common application of the 6-dB hybrid combiner is for distortion measurements on amplifiers, mixers, or complete systems, discussed in Chap. 6.

The return loss bridge is never perfect. Some resistor values may be different than the bridge characteristic impedance. Stray capacitance and inductance may cause some arms of the bridge to differ from others. When a "perfect" Z_0 load is placed on the output, a finite reflection coefficient, or return loss will be measured. This is called the directivity of the bridge.

Return loss bridges are easily constructed, even in the home laboratory, with available components. They will show a directivity of 30 dB or more in the hf spectrum and at least 20 dB throughout the vhf spectrum if some care is used in construction (11).

RLB's using the same circuit as presented can be built that perform well into the microwave region. However, lead lengths, symmetry, and component quality all become critical (12).

The return loss bridge may be used for combining or splitting signals. It has the disadvantage that it dissipates power. Figure 4.35 shows a hybrid that overcomes this problem, the so-called zero-degree hybrid. The circuit is drawn in two forms to illustrate the circuits found in the literature. The form of Fig. 4.35a is used for analysis of the hybrid in a power splitter application. The assumed current directions are labeled.

Transformer current action forces $i_1 = i_2$. A nodal equation at the input shows $i_s = i_1 + i_3$. Finally, the voltage behavior of the transformer leads to $V_{in} - V_1 = V_2 - V_{in}$. These conditions are used to formulate a set of equations that may be solved for V_1, V_2, and V_{in} for specific component values. The results of such an analysis shows that R_3, the balancing resistor should have a value of $2R_1$ when R_1 and R_2 are equal. The input resistance is then $\frac{1}{2}R_1$. For example, if the two terminations are each 50 Ω, a 100-Ω unit is used for R_3 and the input resistance is 25 Ω. The available power from the source is evenly split between the two loads, R_1 and R_2. If one load changes, the power delivered to the other remains constant. The effect of the change in a termination causes the excess power to be dissipated in the balancing resistor. There is no loss in the circuit when equally terminated. The input resistance will, however, change as either output termination varies.

This circuit is also used for combining signals, as shown in Fig. 4.35c. The isolation between input ports is excellent, although driving impedances will be reflected through to the output. There is no phase shift caused by the circuit when used in either splitter or combiner applications.

Another hybrid is the so-called quadrature coupler. This type is not easily built to cover wide frequency ranges. The usual circuit at microwave frequencies uses

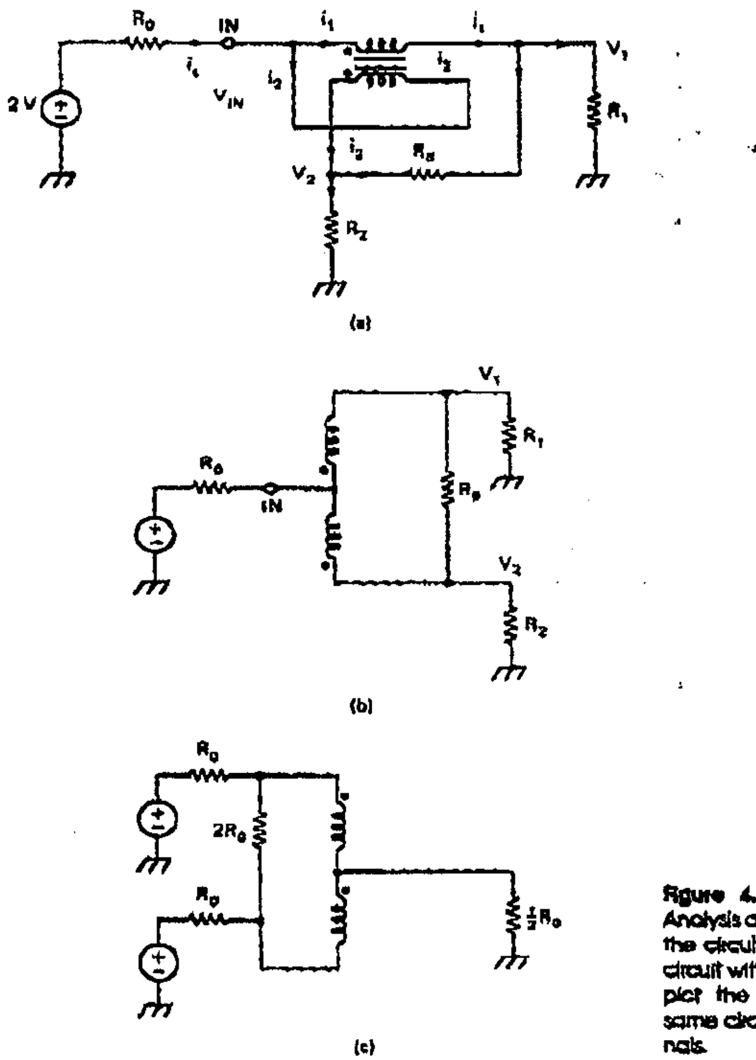

Figure 4.35 A zero degree hybrid. Analysis as a power splitter is done with the circuit at (a). (b) shows the same circuit with a different form used to depict the transformer. (c) shows the same circuit used to combine two signals.

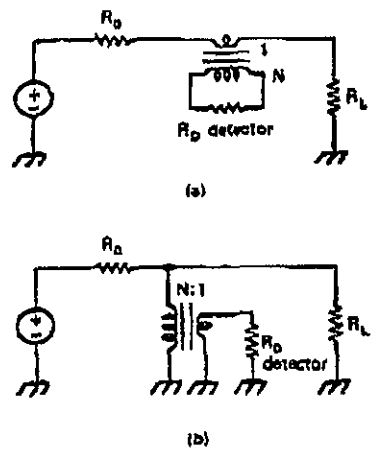

Figure 4.36 Couplers using transformers. That at (a) samples the current in the transmission line while (b) samples the voltage on the line.

microstrip techniques (13). The virtue of a quadrature coupler, one with a 90 degree phase difference between input and output, is that it allows a constant impedance to be presented at one port when variations are encountered at another.

The hybrids discussed have been conceptually simple. Their operation is explained on the basis of voltages and currents with no regard for wave phenomenon. Other bridge or coupler circuits come closer to being wave related in their operation.

Figure 4.36 shows two couplers, devices that sample some of the energy in a line. Each coupler uses a transformer. The current in the line is sampled at Fig. 4.36a. Assume that the load is matched to the source. The transformer has a single-turn primary and a secondary of N turns. The R_0 termination on the secondary has the effect of placing a resistance of R_0/N^2 in series with the line. If N is reasonably high, the equivalent series resistance is low. The current flowing is dominated by the load and not by the coupler. The current flowing in the detector will be that in the line divided by N. Hence, the power available at the detector will be $1/N^2$ of that flowing into the load. A 20-dB coupler results if $N = 10$.

Figure 4.36b is similar except that voltage is sampled. The impedance presented at the N-turn primary is N^2R_0, a value usually high with respect to the load. The detector voltage is that across the load diminished by $1/N$. An N^2 power relationship still applies.

Both couplers are useful devices in rf measurements. However, they tell us nothing about impedances. The two may be combined to form a directional coupler, a device that will provide wave related information. This is shown in Fig. 4.37.

Assume that all resistors are 1 Ω and that the open circuit generator voltage is 2. The current flowing into the load will be 1 A. This current flows into the dot of the single-turn winding of T_1, forcing an output current from the dot of the N-turn winding of $1/N$ ampere. Because of symmetry, a current of $1/(2N)$ is forced into each of the detector resistors.

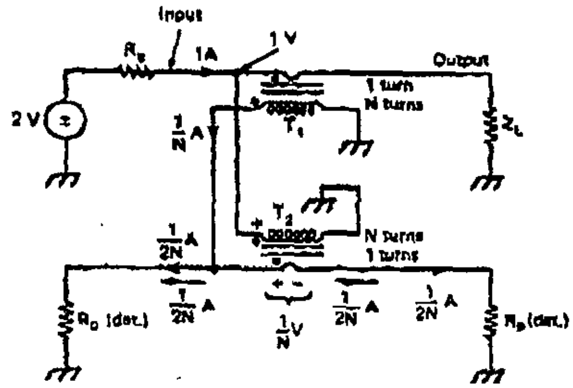

Figure 4.37 A directional coupler using two transformers.

Transformer T_2 samples the voltage across the load. A positive load voltage yields an output of $1/N$ volts at the secondary. A positive polarity appears at the dot on the single turn of T_2. This voltage causes a current to flow in the two terminating resistors, the detectors. The current is $1/(2N)$. These currents are indicated as arrows separated from the connecting wires in the schematic. The current resulting from the voltage sampling flows to the left, into the left termination, and out of the right detector. The total current into the left detector is $1/N$ while it is zero into the right detector. The coupling power ratio is again $1/N^2$.

Allow the role of the input and the output to be reversed with the output termination appearing at the "input" terminal and the generator at the "output." The load voltage is identical. However, the direction of the current is opposite. The net result is coupling of power in the ratio of $1/N^2$ to the right detector and no power to the left detector.

There will be a reflected wave if the load has a normalized value other than 1. The power at the right detector is representative of the reflected wave while that at the left detector is a sample of the incident wave. A reactive termination will lead to phase differences between the voltage and current in the load which is again coupled to the ports. The function of the directional coupler is exactly the same as the return loss bridge with the addition of a port that provides information about incident energy.

There is an asymmetry in the coupler. The output of T_1 is applied to one side of the secondary of T_2. The voltage sampling by T_2 is from one side of the primary of T_1. This is usually of little significance if N is large. The N-turn windings of each transformer should return to the center of the single-turn winding for best performance. This will improve the directivity of the coupler.

The characteristic impedance of the directional coupler will change if the impedance of the detectors is altered. Although directional couplers are usually used and explained in terms of wave phenomenon, they are really no different than the return loss bridge. Indeed, we note from Sec. 4.2 that the very concept of forward and reverse voltage waves was defined in terms of a specific source impedance. It is only the relationship of these concepts to transmission line behavior that adds relevance to the wave interpretation of directional couplers.

The coupler described in Fig. 4.37 is only one of many types. The basis is common to all though. The current in the line is sampled as is the load voltage. The two are compared in both phase and amplitude, producing a "zero reflected power" indication only when the load equals Z_0. For example, current sampling may be done with a small series resistor. Voltage sampling can be done with a capacitive voltage divider.

Directional couplers are often built with transmission line sections (14). An example is shown in Fig. 4.38 where microstrip is employed. The figure shows only the top pattern; the presence of a dielectric substrate with a ground plane is implicit. Analysis of a transmission line directional coupler is considerably more complicated than the other types described. However, the operation is intuitatively reasonable. Current flowing through the line connecting the source to the load establishes a magnetic field. The close proximity of the coupled line will allow the field to induce currents. Similarly, capacitive coupling between lines will cause a sample of the load voltage to appear on the coupled line. This voltage will also lead to output current. The overall action is the same as was found with the transformer coupler of Fig. 4.37.

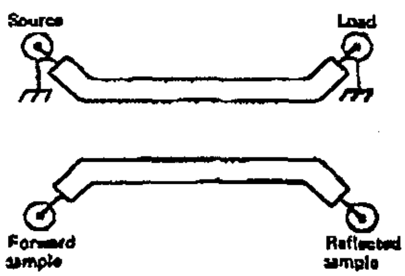

Figure 4.38 A transmission line directional coupler using microstrip. Only the top layer is shown—a dielectric layer and ground plane is assumed under the lines. Interaction of the magnetic fields of the line allow current sampling while electric field coupling allows the voltage on the line to be sampled. The operation is then identical to that of Fig. 4.38, although the bandwidth is restricted.

While our interest in the directional coupler has been for the measurement of complex impedances, with special emphasis on transmission lines, there are many other applications. It is often desired to sample energy from a line for the control of a system. Alternatively, the symmetry of a directional coupler suggests that energy may be injected onto a transmission line through a coupler. As such, they are often used in mixer or summing applications.

A wide variety of coupled transmission line type structures are especially useful at microwave frequencies. Figure 4.39 shows a microstrip-type bandpass filter. The input is a section of line that is short circuited. The input match would be poor if there were no other elements available, for all of the incident energy would be reflected by the short. However, the input line, l_1, is part of a directional coupler with l_2 forming the rest. The second line is not terminated at either end. l_2 is a half wavelength at the desired center frequency, thus forming a resonator. The third line is similar

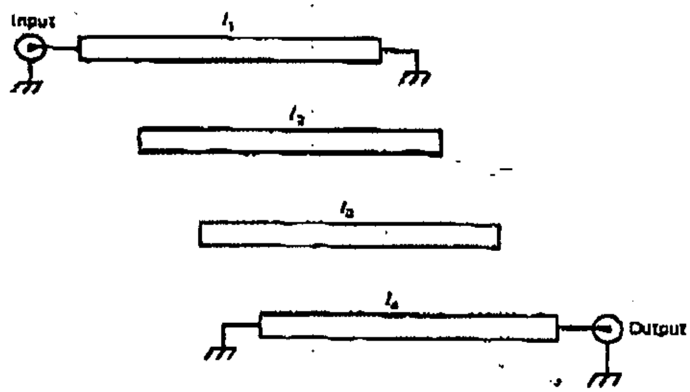

Figure 4.39 A double tuned circuit using sections of microstrip as directional couplers.

with the fourth line acting as a means of extracting energy from the filter. The response of this filter may be tailored to whatever filter response desired through the use of properly designed lines and spacings. All of the methods of Chap. 3 for bandpass filter design may be adapted to these structures. Measurements may be performed with a proper adaptation of the Dishal method.

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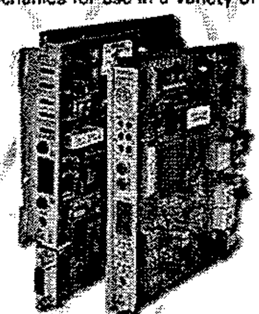

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- MODEL 520-10SW ISSUE 3
- MODEL 520-15SW ISSUE 1
- MODEL 520-50 ISSUE 1
- MODEL 528-15 ISSUE 2
- MODEL 528-20 ISSUE 2
- MODEL 528-30 ISSUE 3

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