7102

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ZESPÓŁ AUTOMATYKI ELEKTRONICZNEJ
Pracownia Elektronicznych Testerów

440 BE10

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Nr zlecenia S 1439

Zbadanie możliwości systemu LONWORKS f-my Echelon wykorzystującego linie energetyczne jako linie sieci komunikacyjnej do zbierania danych w systemach przemysłowych i komunalnych
Etap 2:
Uruchomienie zestawu analizatorów komunikacji w sieci PLE-30 i wykonanie badań funkcjonalnych

Zleceniodawca
Praca statutowa PIAP

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Praca zawiera:

stron 17
rysunków
fotografii
tabel
tablic
załączników

Nr rejestr. 7102

Rozdzielnik - ilość egz:

Egz. 1 BOINTE
Egz. 2 ZAE-1
Egz. 3 ZAE-3
Egz. 4 ZAE
Egz. 5
Egz. 6

1

Analiza deskryptorowa

BADANIA LABORATORYJNE, SYSTEM LONWORKS ECHELON

Analiza dokumentacyjna

Dokumentacja zawiera:
opis zakresu badań, wyniki badań i wnioski z badań funkcjonalnych zestawu PLE-30 systemu LONWORKS firmy Echelon.

Tytuły poprzednich sprawozdań

1. Zbadanie możliwości systemu LONWORKS firmy Echelon wykorzystującego linie energetyczne jako linie sieci komunikacyjnej do zbierania danych o systemach przemysłowych i komunalnych.
etap 1: Opracowanie materiałów firmy Echelon i wygłoszenie seminarium o systemie LONWORKS - nr rej. 7063

UKD

PIAP 41/88 10000

2

Spis treści:

1. ZAKRES BADAŃ:

Badaniom poddano zestaw PLE-30 Power Line Evaluation Kit systemu LonWorks firmy Echelon.
Zestaw ten składa się z dwóch urządzeń elektronicznych stanowiących dwa węzły komputerowqej sieci transmisyjnej. Węzły te mają za zadanie przesyłanie informacji pomiędzy sobą wykorzystując jako ośrodek transmisji kable sieci zasilającej 220 V.

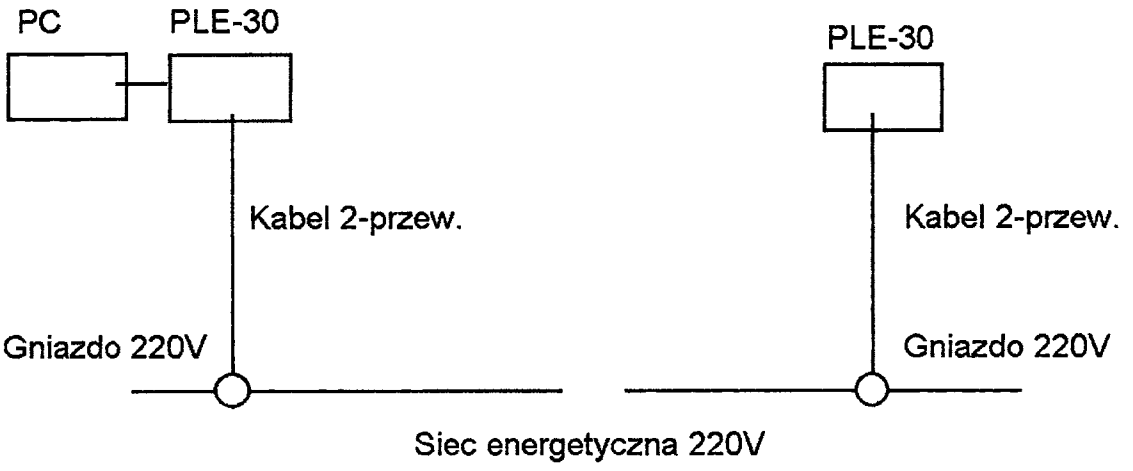
Badania funkcjonalne wykonano w schemacie połączeń zgodnym z dokumentacją User's Guide otrzymaną wraz z zestawem. Schematy połączeń przedstawiono na rysunkach.

PLE-30 to zestaw badawczy tzw. evaluation kit , zawierający węzeł sieci Lon typu LTS-10 z nadajnikiem Power Line Transceiver. LTS-10 jest połączony z komputerem -PC poprzez interfejs RS-232 poprzez który komputer wysyła polecenia przesłania grup różnych przesyłek między dwoma węzłami sieci. Następnie komputer odczytuje z węzłów dane statystyczne o wykonywanej transmisji i zapisuje je do zbiorów, które prezentowane są w niniejszym sprawozdaniu.

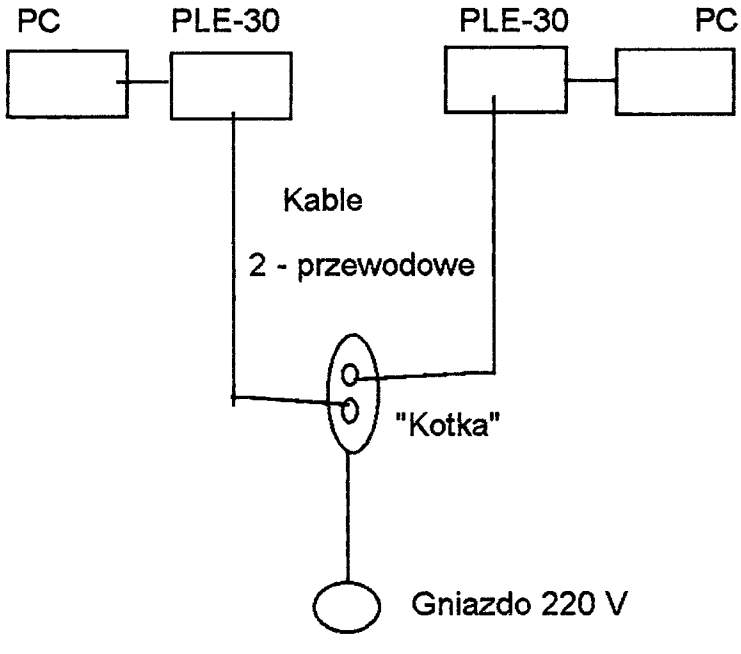
PLE-30 jest zestawem przeznaczonym do nauki nie obudowanym i bez wbudowanych zasilaczy, o dużej powierzchni i długich ścieżkach doprowadzających sygnały na płytce drukowanej.
Został on wypożyczony z firmy Echelon na okres dwu tygodni w celu wstępnej analizy przydatności systemu LonWorks.
.Przeprowadzone badania dotyczyły odporności na zakłócenia występujące w kanale transmisyjnym . Przesyłki wykonywane były w trybie adresowanym (unicast) oraz rozgłaszania (broadcast).

Badania wykonywane były w dwu schematach połączeń. W pierwszym przedstawionym na rys.1 komputer PC oraz nadajnik PLE-30 umieszczone były na stałe w pokoju 207/VI i były zasilane z różnych faz zasilania 220V podczas gdy drugi węzeł PLE-30 był umieszczany w różnych innych pomieszczeniach, włączany do gniazdka sieciowego po czym następowała próba poprzez wywołanie programu w komputerze PC wykonania transmisji 500 przesyłek od nadajnika do odbiornika (z potwierdzeniem lub bez).
W drugim schemacie połączeń (rys.2) wykonywano przesyłanie zbiorów pomiędzy dwoma komputerami PC przy pomocy sieci LonWorks poprzez kable zasilania energetycznego.

Rys. 1. Układ pomiarowy do badania transmisji.



Rys. 2. Układ pomiarowy do badania transmisji.



2. WYNIKI BADAŃ.

Zestawienie wyników wybranych badań

Tryb unicast:

nr	il. wysl	il.odebr	WYNIK	trans/sek	bajt/sek	blad nad.	powtórzenia	blad odb.
1	200	200	+	1,2	155	2	17	2
2	100	100	+	1,4	183	0	0	0
3	500	500	+	1,4	179	3	5	4
4	10	0	-	brak połączenia		zła faza		
5	100	100	+	1,1	mess	49	52	4
6	10	10	+	1,1	mess	10	9	0
7	500	500	+	1,2	148	32	53	40
8	500	500	+	1,4	173	4	13	13
9	10	0	-	brak połączenia		zła faza		
10	500	500	+	1,2	157	5	35	60
Dla wszystkich prób:								
średnie				1,3	164	11	21	15

Dla wszystkich prób, w których obydwa węzły sieci były podłączone do tej samej fazy uzyskano tą samą ilość przesyłek wysłanych co odebranych co oznacza POZYTYWNY WYNIK PRÓBY.

Na następnych stronach przedstawiono wybrane wydruki zbiorów wytwarzanych przez program testujący zestawu PLE-30, będących zestawieniami rezultatów poszczególnych prób.

4

1. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj nr 207/VI

Kable we wspolnej "kotce".

```
Tryb transmisji :  adresowana  z  potwierdzeniem
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       .1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :128
Enter packet count               [500]  :200
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed May 25 09:50:32 1994
Packet count            = 200
Elapsed time            = 165 seconds
Transactions per second = 1.2
Bytes per second        = 155
****Statistics for Network Interface Node
    Packet errors detected      = 2
    Transaction timeouts        = 0
    Packets received by node    = 200
    Packets addressed to node   = 200
    Messages sent to MAC layer  = 217
    Retries                     = 17
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 21
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 201
    Packets addressed to node   = 201
    Messages sent to MAC layer  = 201
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :N
Enter data length (1-31)         [1]    :128
Maximum data length is 31 bytes
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 17

WYNIK BADANIA POZYTYWNY

2. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj rr 207/VI

Transmisja po kablu zasilania bez dolaczenia 220V.

```
Tryb transmisji :  adresowana  z  potwierdzeniem
BENCH>
Didn't recognize that command, valid commands are:
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :128
Enter packet count               [500]  :100
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed May 25 10:02:34 1994
Packet count            = 100
Elapsed time            = 70 seconds
Transactions per second = 1.4
Bytes per second        = 183
****Statistics for Network Interface Node
    Packet errors detected      = 0
    Transaction timeouts        = 0
    Packets received by node    = 100
    Packets addressed to node   = 100
    Messages sent to MAC layer  = 100
    Retries                     = 0
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 0
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 100
    Packets addressed to node   = 100
    Messages sent to MAC layer  = 100
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 0

WYNIK BADANIA POZYTYWNY

3. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj nr korytarz/VI.

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 500
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Tue May 31 09:53:53 1994
Packet count            = 500
Elapsed time            = 357 seconds
Transactions per second = 1.4
Bytes per second        = 179
****Statistics for Network Interface Node
    Packet errors detected      = 3
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 505
    Retries                     = 5
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 4
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 502
    Packets addressed to node   = 502
    Messages sent to MAC layer  = 502
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 5

WYNIK BADANIA POZYTYWNY

4. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami.

1. pokoj nr 207/VI 2. pokoj 15/VI

```
Tryb transmisji :  adresowana  z  potwierdzeniem
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :
Enter packet count               [500]  :10
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
Message failed completion: reading node memory
Cannot access remote node(s)
```

Wnioski: Brak komunikacji pomiedzy wezlami sieci.

WYNIK BADANIA NEGATYWNY

11

5. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami.

1. pokoj nr 207/VI 2. pokoj nr 12/VI.

Tryb transmisji : adresowana z potwierdzeniem

```
=====> Starting benchmark at Tue May 31 11:51:16 1994
Packet count            = 100
Elapsed time            = 94 seconds
Transactions per second = 1.1
Bytes per second        = 0
****Statistics for Network Interface Node
    Packet errors detected      = 49
    Transaction timeouts        = 0
    Packets received by node    = 100
    Packets addressed to node   = 100
    Messages sent to MAC layer  = 152
    Retries                     = 52
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 4
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 149
    Packets addressed to node   = 149
    Messages sent to MAC layer  = 149
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :128
Enter packet count               [500]  :500
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Tue May 31 11:53:39 1994
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 52

WYNIK BADANIA POZYTYWNY

6. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj jadalnia DW.

Tryb transmisji : adresowana z potwierdzeniem

```
Is this OK? ([Y]/N)                    :Y
=====> Starting benchmark at Tue May 31 11:30:43 1994
Packet count            = 10
Elapsed time            = 9 seconds
Transactions per second = 1.1
Bytes per second        = 0
****Statistics for Network Interface Node
    Packet errors detected      = 10
    Transaction timeouts        = 0
    Packets received by node    = 10
    Packets addressed to node   = 10
    Messages sent to MAC layer  = 19
    Retries                     = 9
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 0
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 19
    Packets addressed to node   = 19
    Messages sent to MAC layer  = 19
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 9

WYNIK BADANIA POZYTYWNY

7. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj nr 12/VI.

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :128
Invalid node ID
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :128
Enter packet count               [500]  :
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Tue May 31 13:07:47 1994
Packet count            = 500
Elapsed time            = 431 seconds
Transactions per second = 1.2
Bytes per second        = 148
****Statistics for Network Interface Node
    Packet errors detected      = 32
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 553
    Retries                     = 53
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 40
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 529
    Packets addressed to node   = 529
    Messages sent to MAC layer  = 529
BENCH> Redirect (O)utput to a file
```

Wnioski: Wszystkie pakiety przesłane prawidlowo
ilosc koniecznych powtornych przesylek = 53

WYNIK BADANIA POZYTYWNY

8. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj nr 12/VI.

Nadawanie w fazie T

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length      = 128
Packet count     = 500
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Tue May 31 13:15:53 1994
Packet count             = 500
Elapsed time             = 369 seconds
Transactions per second = 1.4
Bytes per second         = 173
****Statistics for Network Interface Node
    Packet errors detected      = 4
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 513
    Retries                     = 13
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 13
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 504
    Packets addressed to node   = 504
    Messages sent to MAC layer  = 504
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 13

WYNIK BADANIA POZYTYWNY

9. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. pokoj nr 12/VI.

Nadawanie w fazie R

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :
Enter packet count               [500]  :10
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
Message failed completion: reading node memory
Cannot access remote node(s)
BENCH> Redirect (O)utput to a file
```

Wnioski: Brak transmisji

WYNIK BADANIA NEGATYWNY

10. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :128
Enter packet count               [500]  :
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed Jun 01 09:03:13 1994
Packet count            = 500
Elapsed time            = 408 seconds
Transactions per second = 1.2
Bytes per second        = 157
****Statistics for Network Interface Node
    Packet errors detected      = 5
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 535
    Retries                     = 35
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 60
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 503
    Packets addressed to node   = 503
    Messages sent to MAC layer  = 503
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 35

WYNIK BADANIA POZYTYWNY

11. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 500
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Wed Jun 01 09:10:56 1994
Packet count            = 500
Elapsed time            = 399 seconds
Transactions per second = 1.3
Bytes per second        = 160
****Statistics for Network Interface Node
    Packet errors detected      = 4
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 530
    Retries                     = 30
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 37
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 504
    Packets addressed to node   = 504
    Messages sent to MAC layer  = 504
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesyłek = 37

WYNIK BADANIA POZYTYWNY

12. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 500
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Wed Jun 01 09:42:12 1994
Packet count            = 500
Elapsed time            = 366 seconds
Transactions per second = 1.4
Bytes per second        = 175
****Statistics for Network Interface Node
    Packet errors detected      = 3
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 510
    Retries                     = 10
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 13
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 502
    Packets addressed to node   = 502
    Messages sent to MAC layer  = 502
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 10

WYNIK BADANIA POZYTYWNY

13. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 500
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Wed Jun 01 09:55:57 1994
Packet count            = 500
Elapsed time            = 363 seconds
Transactions per second = 1.4
Bytes per second        = 176
****Statistics for Network Interface Node
    Packet errors detected      = 2
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 509
    Retries                     = 9
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 9
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 501
    Packets addressed to node   = 501
    Messages sent to MAC layer  = 501
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 9

WYNIK BADANIA POZYTYWNY

14. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 500
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Wed Jun 01 10:33:56 1994
Packet count            = 500
Elapsed time            = 370 seconds
Transactions per second = 1.4
Bytes per second        = 173
****Statistics for Network Interface Node
    Packet errors detected      = 4
    Transaction timeouts        = 0
    Packets received by node    = 500
    Packets addressed to node   = 500
    Messages sent to MAC layer  = 513
    Retries                     = 13
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 13
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buf*)   = 0
    Packets received by node    = 502
    Packets addressed to node   = 502
    Messages sent to MAC layer  = 502
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 13

WYNIK BADANIA POZYTYWNY

15. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : grupowa z potwierdzeniem i badaniam prawa dostepu

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Multicast (group)
(N)etwork variable or (M)essage? [M]    :N
Enter data length (1-31)         [1]    :30
Enter packet count               [500]  :
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :Y
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed Jun 01 10:54:44 1994
Packet count            = 500
Elapsed time            = 268 seconds
Transactions per second = 1.9
Bytes per second        = 56
****Statistics for Network Interface Node
    Packet errors detected      = 7
    Transaction timeouts        = 0
    Packets received by node    = 1001
    Packets addressed to node   = 1001
    Messages sent to MAC layer  = 1007
    Retries                     = 6
    Late acks or responses      = 0
    Collisions detected         = 0
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 7

WYNIK BADANIA POZYTYWNY

16. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem i sprawdzaniem prawa dostepu

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :N
Enter data length (1-31)          [']   :16
Enter packet count                [500] :
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :Y
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed Jun 0' 11:19:27 1994
Packet count            = 500
Elapsed time            = 229 seconds
Transactions per second = 2.2
Bytes per second        = 35
****Statistics for Network Interface Node
    Packet errors detected      = 4
    Transaction timeouts        = 0
    Packets received by node    = 1002
    Packets addressed to node   = 1002
    Messages sent to MAC layer  = 1009
    Retries                     = 7
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 4
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 1005
    Packets addressed to node   = 1005
    Messages sent to MAC layer  = 1005
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 7

WYNIK BADANIA POZYTYWNY

17. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :160
Enter packet count               [500]  :2000
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :Y
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed Jun 01 12:22:31 1994
Packet count            = 1360
Elapsed time            = 1630 seconds
Transactions per second = 0.8
Bytes per second        = 133
****Statistics for Network Interface Node
    Packet errors detected      = 22
    Transaction timeouts        = 0
    Packets received by node    = 2752
    Packets addressed to node   = 2752
    Messages sent to MAC layer  = 2836
    Retries                     = 84
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 126
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 2765
    Packets addressed to node   = 2765
    Messages sent to MAC layer  = 2765
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 84

WYNIK BADANIA POZYTYWNY

18. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH>
Didn't recognize that command, valid commands are:
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast, or (U)nicast  :Unicast (subnet/node)
Enter node id for destination [0]       :1
(N)etwork variable or (M)essage? [M]    :M
Enter data length (0-160)        [0]    :128
Enter packet count               [50C]  :200
Acknowledged service? (Y/[N])           :Y
Authenticated? (Y/[N])                  :N
Is this OK? ([Y]/N)                     :Y
=====> Starting benchmark at Wed Jun 01 12:50:03 1994
Packet count            = 200
Elapsed time            = 149 seconds
Transactions per second = 1.3
Bytes per second        = 172
****Statistics for Network Interface Node
    Packet errors detected      = 1
    Transaction timeouts        = 0
    Packets received by node    = 200
    Packets addressed to node   = 200
    Messages sent to MAC layer  = 206
    Retries                     = 6
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 7
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 201
    Packets addressed to node   = 201
    Messages sent to MAC layer  = 201
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 6

WYNIK BADANIA POZYTYWNY

19. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 200
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Wed Jun 01 12:52:41 1994
Packet count            = 200
Elapsed time            = 145 seconds
Transactions per second = 1.4
Bytes per second        = 177
****Statistics for Network Interface Node
    Packet errors detected      = 4
    Transaction timeouts        = 0
    Packets received by node    = 200
    Packets addressed to node   = 200
    Messages sent to MAC layer  = 203
    Retries                     = 3
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 3
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 202
    Packets addressed to node   = 202
    Messages sent to MAC layer  = 202
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 3

WYNIK BADANIA POZYTYWNY

20. Sprawdzenie poprawnosci transmisji pomiedzy pomieszczeniami:

1. pokoj nr 207/VI 2. hala produkcyjna DW

Nadawanie w fazie S

Tryb transmisji : adresowana z potwierdzeniem

```
BENCH> (R)epeat last benchmark
Unicast addressing to node 1
Explicit message
Data length     = 128
Packet count    = 200
Acknowledged service
Is this OK? ([Y]/N) :Y
=====> Starting benchmark at Wed Jun 01 12:56:08 1994
Packet count            = 200
Elapsed time            = 151 seconds
Transactions per second = 1.3
Bytes per second        = 170
****Statistics for Network Interface Node
    Packet errors detected      = 0
    Transaction timeouts        = 0
    Packets received by node    = 200
    Packets addressed to node   = 200
    Messages sent to MAC layer  = 207
    Retries                     = 7
    Late acks or responses      = 0
    Collisions detected         = 0
****Statistics for Remote Node
    Packet errors detected      = 10
    Lost msgs (no app buff)     = 0
    Missed msgs (no net buff)   = 0
    Packets received by node    = 200
    Packets addressed to node   = 200
    Messages sent to MAC layer  = 200
BENCH> (E)xit this application and return to DOS
Do you really want to exit? (Y/[N]) :Y
Message failed completion: reading node memory
Rebooted node #0
Leaving the PLE-30 network interface benchmark program
```

Wnioski: Wszystkie pakiety przeslane prawidlowo
ilosc koniecznych powtornych przesylek = 7

WYNIK BADANIA POZYTYWNY

3. Wnioski z badań funkcjonalnych.

Ze względu na bardzo duży koszt zakupu systemu LonWorks (20 000$) , skorzystano z możliwości wypożyczenia na okres dwu tygodni urządzenia przeznaczonego do nauki systemu, PLE-30 aby przeprowadzić chociaż wstępne rozeznanie możliwości zastosowań tego systemu w przemyśle w polskich warunkach.
W związku z powyższym wykonane badania funkcjonalne traktować należy jako badania modelu laboratoryjnego węzła sieci LonWorks. Badania wykonywane były na zestawie badawczym "evaluation kit " , nie obudowanym i bez własnych zasilaczy.

W wyniku przeprowadzonych badań stwierdzono że:

- transmisja odbywa się prawidłowo pomiędzy budynkiem nrVI i halą produkcyjną DW - to jest na odległość ok 60m - w czasie pracy, włączania i wyłączania maszyn.
- zakłócenia występujące w sieci powodują przy trybie transmisji z potwierdzeniem wydłużenie czasu transmisji określonej ilości przesyłek, ze względu na konieczność powtórnego przesyłania zakłóconych przesyłek.
- przy odległosci pomiędzy węzłami ok 10m transmisja odbywa się prawidłowo poprzez pojemności równolegle ułożonych kabli różnych faz zasilania (nadajnik faza S - odbiornik faza T).
- przy przesyłaniu grupy 500 przesyłek kolejno ilość wymaganych powtórzeń transmitowanej przesyłki wynikająca z zakłóceń w sieci wynosiła od 0 do 53 a więc od 0 do 10%.

WNIOSKI KOŃCOWE:

Wyniki przeprowadzanych badań potwierdzają podawane przez producenta możliwości transmisji sygnałów poprzez kable sieci zasilającej 220V.

Należy w przyszłości przeprowadzić badania odporności na zakłócenia urządzeń systemu LonWorks w standardowym wykonaniu i dla narażeń przewidzianych w dokumentach normalizacyjnych dla systemów automatyki przemysłowej oraz sprawdzić transmisję przy większej ilości węzłów sieci i większym ich rozłożeniu w przestrzeni.
Wyniki przeprowadzonych badań pozwalają przypuszczać, że badania takie dadzą wynik pozytywny.

LonWorks™

PLE-30 Power Line Evaluation Kit

User's Guide

Version 1

ECHELON®
Corporation

078-0111-01A

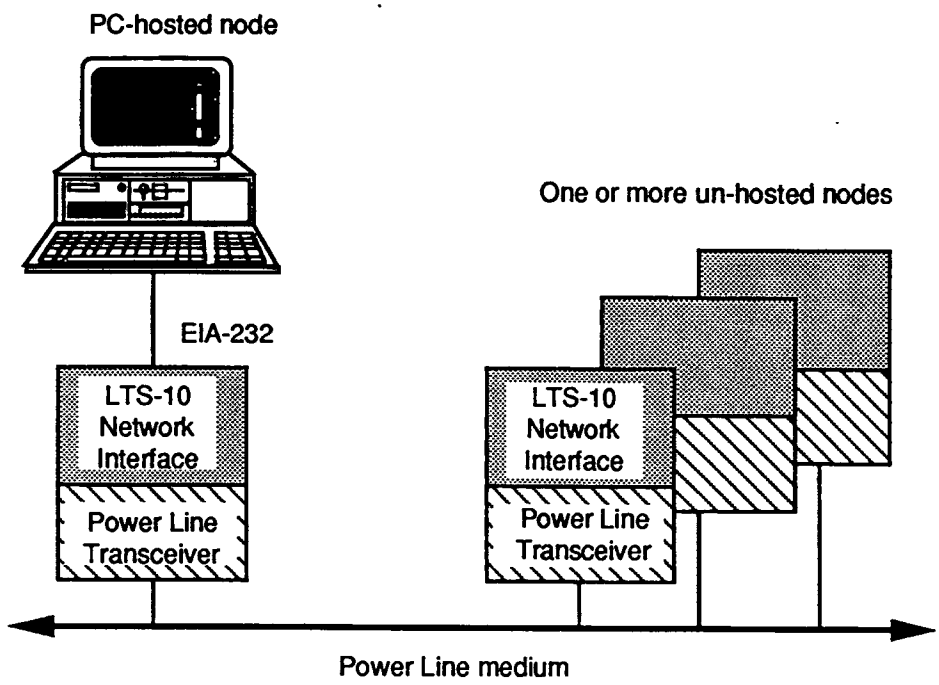


Figure 1.1 Basic Configuration

The basic configuration allows you to carry out the following tests:

- Send messages from the host to any of the remote nodes using the basic transport protocol of LonTalk, which is unacknowledged service. In this case, messages may be sent to an individual node (unicast), or broadcast to all of them.
- Send messages from the host to any of the remote nodes using the most reliable transport protocol of LonTalk, which is acknowledged service.
- Send messages from the host to any of the remote nodes using the authenticated transport protocol for applications that require enhanced security.

In each case, you can investigate the effects of the following parameters on the total message throughput. These parameters include:

- Whether messages are sent using broadcast, multicast (group), or unicast (node) addressing. A message sent with broadcast addressing is addressed to all nodes in a subnet or domain. A message sent with multicast addressing is sent to a group of nodes. Any node can belong to up to 15 groups at a time, and it is possible to use acknowledged service if the group size is 63 nodes or less. For larger groups, unacknowledged or repeated service may be used. Broadcast and multicast addressing both conserve the use of channel bandwidth compared to the alternative, which is individually addressing each node.
- The remote destination node(s) location. For a noisy medium such as power line, the various impairments between the host node and the destination node can be investigated.

- Whether messages are sent as network variables or application messages. Application messages allow unformatted data to be exchanged between nodes; network variables simplify communication and provide interoperability.
- Size of the data in each packet, from 0 to 160 bytes.

At the conclusion of the test, the following statistics are reported.

- Number of packet errors detected. This indicates a false carrier detection, a packet corrupted by noise on the channel, or a collision.
- Lost and missed messages - the number of times the host node could not receive a packet due to lack of buffering.
- Number of valid messages received by the host node with any destination address.
- Number of valid messages addressed to the host node.

In addition to these statistics, the host node can also report the following:

- Number of transaction timeouts - no acknowledgment or response received.
- Number of messages sent to the Media Access Control processor.
- The number of retried messages.
- Number of late acknowledgments or responses.
- The number of collisions detected. A collision is reported when the transceiver detects a signal in the transmission band at the beginning of transmitting a packet.

A built-in scripting facility allows you to run a series of unattended benchmarks, varying each of the above parameters according to the script you provide. The Bench software reads a text file and interprets its contents as though they were entered from the keyboard. Benchmarks may be run at delayed intervals, so that you can evaluate the effects of a time-varying medium such as the power line. The results of the commands may be sent to a text file for later analysis.

Advanced Configuration

With the addition of one or more remote PCs, the **advanced configuration** supports all of the above tests with the additional options discussed below. Once the advanced configuration has been set up, all tests can be carried out from the host PC without the need to physically access the remote PCs. The advanced configuration may be exercised using the F command of the Bench software (see Chapter 4).

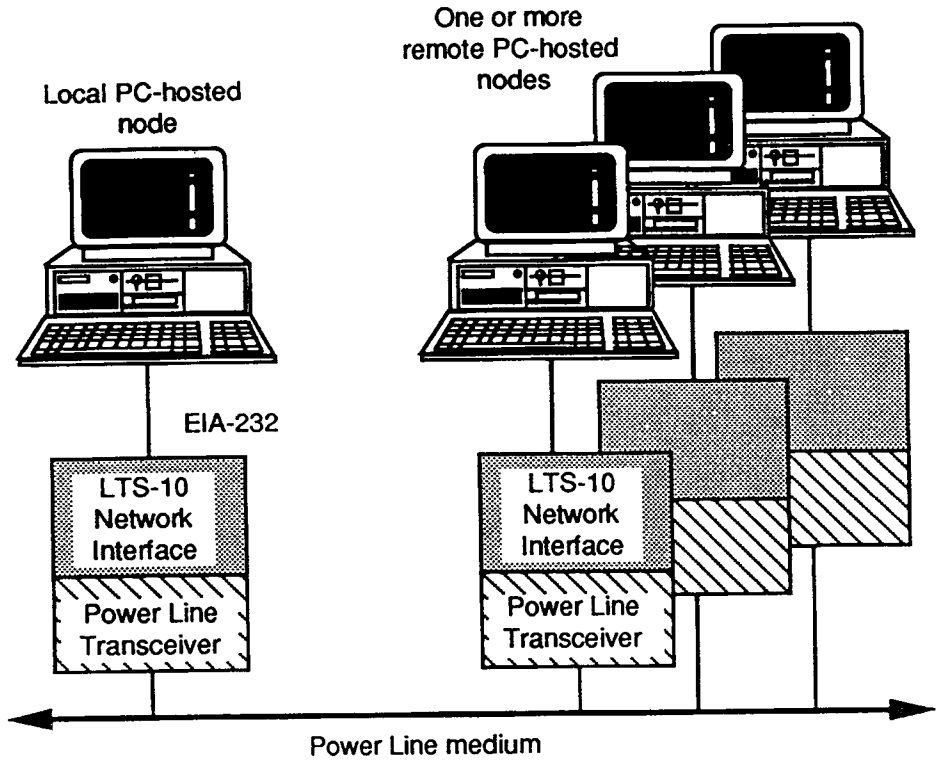


Figure 1.2 Advanced Configuration

Additional options available with the advanced configuration include the ability to:

- Transfer data files between the host and any of the remote nodes using the LonTalk file transfer protocol, which is a reliable sequenced window protocol. This protocol uses a combination of unacknowledged and request/response service to provide reliability together with high data throughput. This facility is provided to allow you to verify that the LonTalk protocol stack transfers data in an error-free way. Errors may be recovered at various layers of the protocol. If all error recovery fails, the destination file is deleted. At the conclusion of each file transfer, the elapsed time and throughput in bytes per second is reported, together with the number of retries required, and the retry rate in percent of packets sent.
- Execute non-interactive DOS commands at any of the remote nodes from the host node keyboard. For example `DIR` may be used to list directories on a remote node on the host node's screen, `CD` may be used to change the current directory on the remote node, and `TYPE` may be used to view a file from the remote node on the host node's screen. This facility allows you to perform simple directory management of the remote nodes from the host without physically having to access the remote node keyboards.

Evaluation Kit Setup

Figure 2.1 below illustrates how the various parts of the PLE-30 Evaluation Kit fit together.

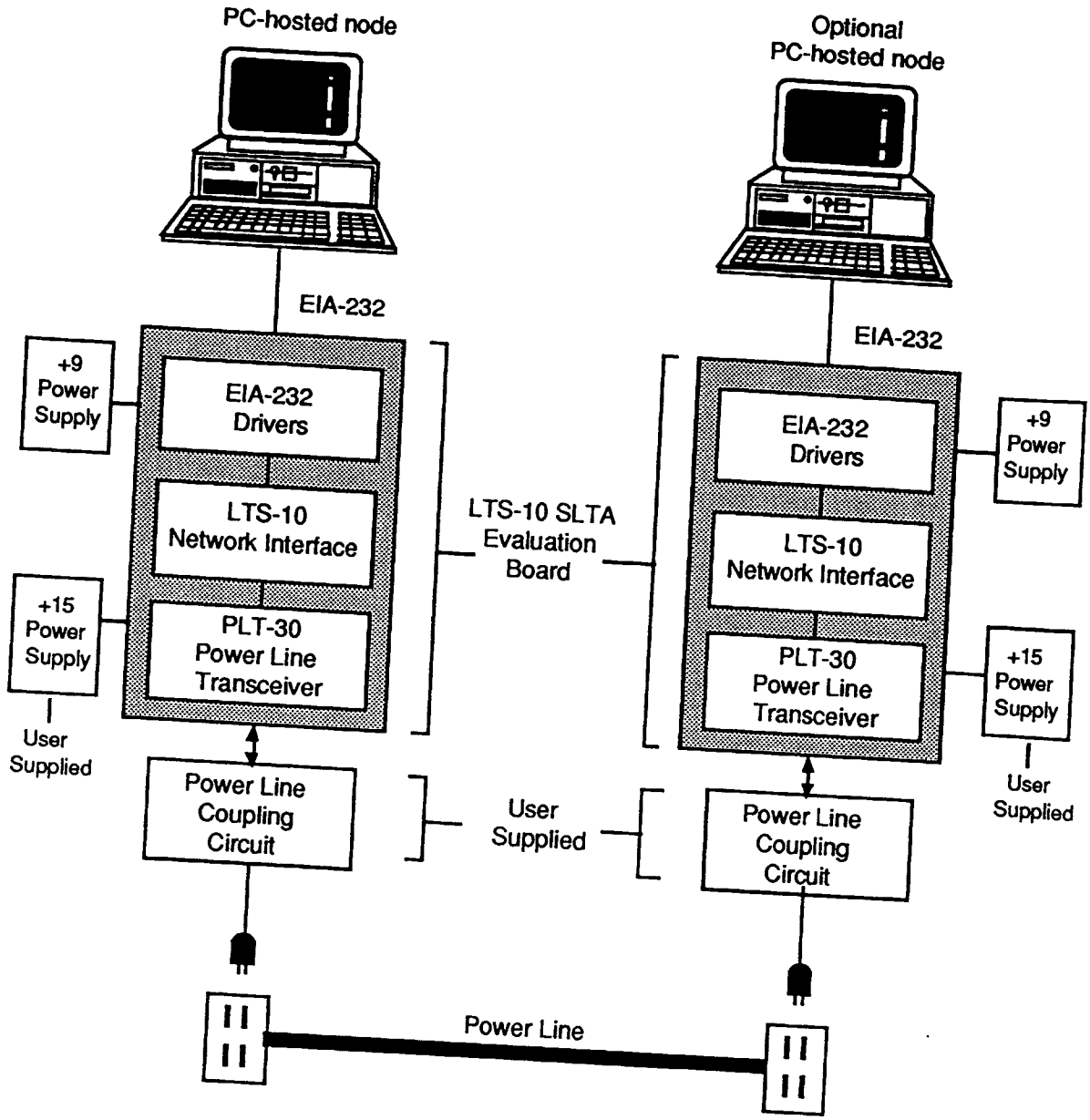


Figure 2.1 Evaluation Kit Configuration

The following items must be provided by the user:

- +15VDC linear, well regulated, power supply (one per node)
- Power line coupling circuit (one per node). Some components are provided with the PLE-30 kit to assist the user in implementing the coupling circuits.
- BNC connectors for connection of the power line coupling circuits to the LTS-10 SLTA evaluation board
- Power cord for connection of the coupling circuits to the power line

Evaluation Board Interfaces

Figure 2.2 shows the layout of the connectors, jumpers, switches and LEDs on the LTS-10 SLTA Evaluation Board.

The LTS-10 SLTA Core Module must be mounted on the LTS-10 Evaluation Board. Also, the S1 and S2 DIP switches have been configured for proper operation but should be checked against tables 2.1 and 2.2. You must supply a +15VDC regulated supply and a coupling circuit for each LTS-10 SLTA Evaluation Board as described later in this chapter.

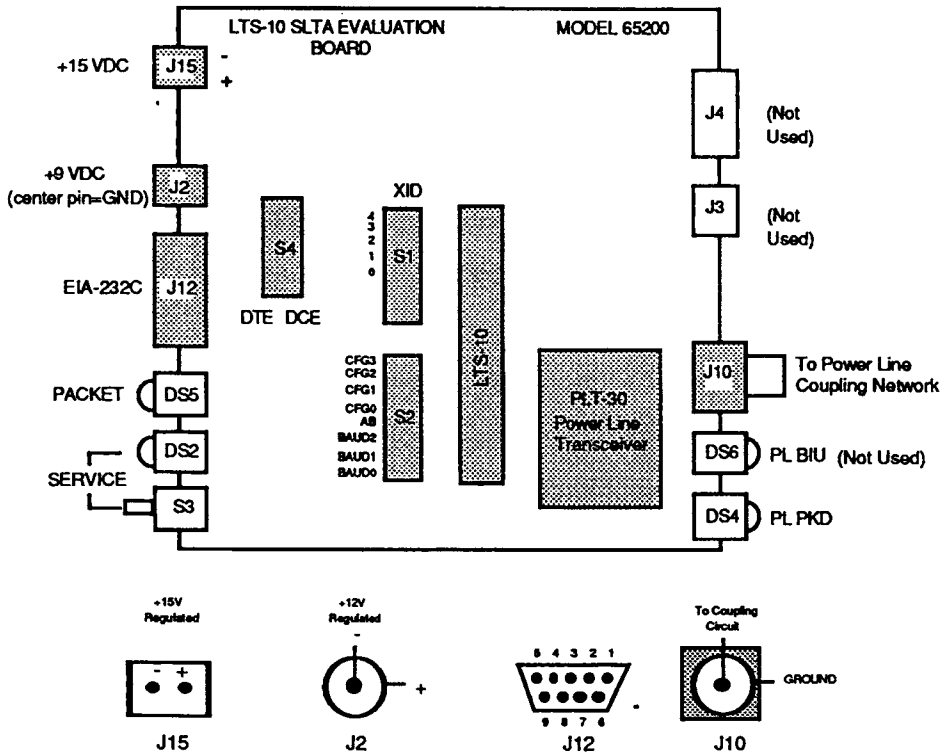


Figure 2.2 LTS-10 SLTA Evaluation Board Interfaces

Using the straight-through serial cable supplied with the kit, connect J12 on the LTS-10 SLTA Evaluation Board to the serial port of your PC corresponding to the DOS COM2 device. Leave the S4 jumpers in their default position (DCE). Use the DB-9 to DB-25 adapter, supplied with the kit, if your PC's serial port has a 25-pin connector. If you use a serial port other than COM2, modify the value of the /P switch in the CONFIG.SYS command line (see Chapter 3).

S2 Dip Switches

The S2 DIP switches allow you to set the basic configuration options for the serial EIA-232 portion of the LTS-10 SLTA Evaluation Board. For optimum performance set the S2 DIP switches on each LTS-10 SLTA Evaluation Board to the settings in table 2.1.

Table 2.1 Configuration Switch Settings

S2

Switch	State	Meaning
CFG 3	OFF	ALERT/ACK protocol
CFG 2	OFF	Local host
CFG 1	OFF	Network enabled
CFG 0	OFF	3 wire interface enabled
AB	OFF	Autobaud disabled
BAUD 2	ON	Serial Bit Rate 115,200 bps
BAUD 1	ON	
BAUD 0	ON	

Transceiver ID DIP Switches

The transceiver ID DIP S1 switches allow you to operate your LTS-10 SLTA Evaluation Board using one of the several available LONWORKS transceivers. Since the PLE-30 kit is supplied with the PLT-30 transceiver, set the S1 switches to the appropriate value for the PL-30 power line transceiver from table 2.2. See the *Serial LonTalk Adapter and Serial Gateway User's Guide* for a description of the transceiver options.

Table 2.2 Transceiver ID Switch Settings

S1

Transceiver	XID 4	XID 3	XID 2	XID 1	XID 0
PL-30	ON	OFF	OFF	ON	OFF

Power Line Coupling Circuit

The coupling circuit connects the LTS-10 SLTA Evaluation Board to the power line, as shown in figure 2.1. The PLE-30 Evaluation Kit is supplied with a parts kit containing a transformer and a capacitor, to aid in the implementation of the coupling circuit.

Note: As with any work involving high voltages, use extreme caution when interfacing to the AC power line mains.

The PLE-30 Power Line Evaluation Kit uses a coupling circuit referred to as *isolated-differential mode* coupling. The schematic for the coupling circuit is shown in figure 2.3.

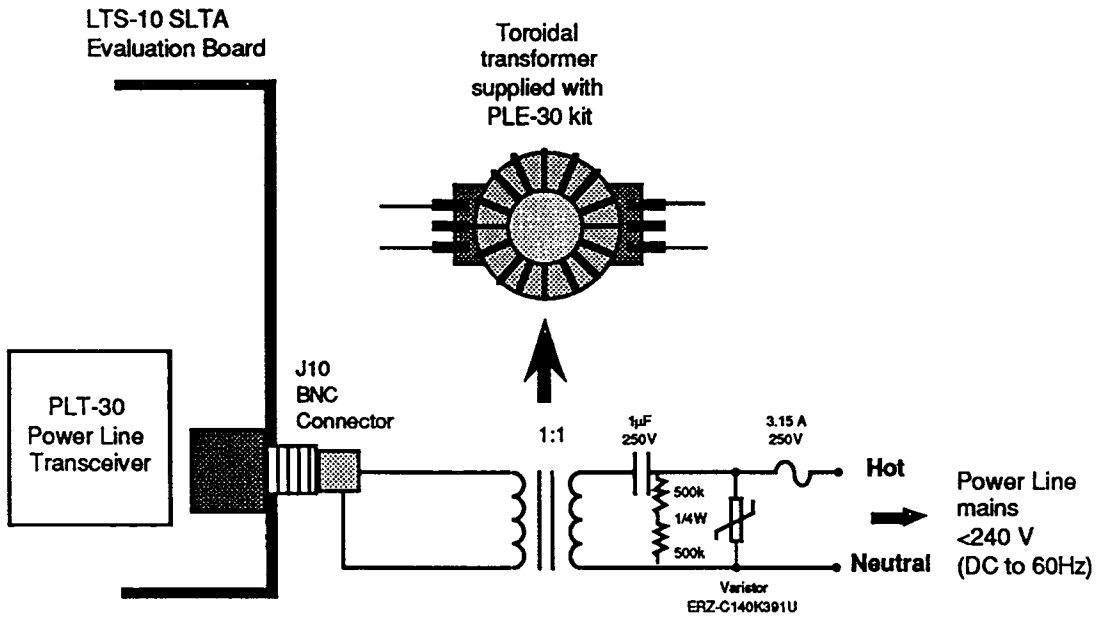


Figure 2.3 Coupling Circuit Interface to the LTS-10 SLTA Evaluation Board.

Both the transformer and the 1µF capacitor are supplied with the PLE-30 kit. The transformer provides electrical isolation while providing a 50-60Hz blocking filter in conjunction with the 1µF capacitor.

The 1µF capacitor is capable of retaining a substantial charge even when the system has been disconnected from the power line. The user-supplied 500kΩ (1/4w) bleeder resistors ensure that the capacitor is discharged when not connected to the power line, in order to minimize any potential shock hazard. Two resistors are used to allow standard resistors to meet a 240V breakdown requirement.

Power Supply Requirements

The LTS-10 SLTA Evaluation Board requires the user to supply +9VDC @ 250mA and +15VDC @ 600mA (maximum while transmitting). In order to optimize the PLT-30 transceiver's communication capability, some care must be exercised in system design to insure that the +15V power supply does not limit overall performance. Since the +15V power supply is directly connected to the communication channel, it has the potential to attenuate the transmit signal and couple noise directly into a receiver input.

Fortunately, most linear power supplies do not load the transmitted signal, nor do they generate significant electrical noise. ***For this reason, linear power supplies/regulators are recommended for the LTS-10 SLTA Evaluation Board's +15V input.***

Switching power supplies are capable of limiting system performance and therefore require special design considerations. While simple filtering can be designed to allow the use of switching power supplies, the design requirements are beyond the scope of this document.

Never place an electromagnetic interference (EMI) filter between the coupling circuit and the power line. An EMI filter will significantly attenuate the communication signal. If an EMI filter is required in the end product, the power line coupling circuit should bypass the filter and be connected directly to the power line side of the filter.

The proper sequence for power up must be followed when applying power to the LTS-10 evaluation board. You must remember to apply the +9VDC voltage on the J2 connector **before** applying the +15VDC on the J15 connector. This will prevent the Neuron Chip and the power line circuitry from powering up in a improper state.

```
BENCH> (B)enchmark performance
(B)roadcast, (M)ulticast or (U)nicast     :Unicast (subnet/node)
Enter node id for destination [0]         :1
(N)etwork variable or (M)essage     [M]   :M
Enter data length                   [0]   :25
Enter packet count                  [500] :50
Acknowledged service (Y/[N])              :Y
Authenticated (Y/[N])                     :N
Is this OK? (Y/[N])                       :Y
=====> Starting benchmark at Wed Jan 12 18:01:0496 1994
Elapsed time              = 18 seconds
Transactions per second   = 2.8
Bytes per second          = 69
****Statistics for Network Interface Node
    Packet errors detected        = 3
    Transaction timeouts          = 0
    Packets received by node      = 50
    Packets addressed to node     = 50
    Messages sent to MAC layer    = 53
    Retries                       = 3
    Late acks or responses        = 0
    Collisions detected           = 0
****Statistics for Remote Node
    Packet errors detected        = 0
    Lost msgs (no app buff)       = 0
    Missed msgs (no net buff)     = 0
    Packets received by node      = 53
    Packets addressed to node     = 53
    Messages sent to MAC layer    = 53
```

Interpreting Benchmark Results

For detailed explanations of the individual fields in the benchmark results, see section *S Command*, later in this chapter.

When reviewing the results of running a benchmark, the statistics presented need to be interpreted with an understanding of how the program obtains the statistics and how normal power line induced errors can affect those statistics.

The reported statistics include the user-defined packets that are sent and received during the test, plus two additional messages: one that is sent at the beginning of the test and one that is sent at the end of the test to poll the receiver's results. The additional messages are sent as acknowledged service with 15 retries. The benchmark program subtracts 2 from the "packets received" field to account for these messages, but does not adjust any other statistics. For example, if you run benchmark on a noisy power line, the two control messages might not be received on the first try. Nonetheless, the benchmark program will only subtract 2 from the packets received field. This could cause the statistics reported to appear out of balance.

If you run a benchmark with unicast non-acknowledged service on powerline, it is possible for a retry to appear in the statistics if a retry is required to either start the test or poll the test results.

The statistics also can be affected when a receiver occasionally perceives noise on the power line which resembles the beginning of a packet. The receiver will then activate the Neuron Chip, only to abort the reception one or two bytes later when a false packet is recognized. This zero length false packet will show up at the receiver as an extra "packet error detected." This could make the sum of "packets received by node" and "packet errors detected" be larger than the number of packets sent. These zero length packets are normal on a real powerline and typically occur at a rate of 1 every few minutes.

The number of transactions per second is an indication of the response time between the application processor of the host node (the PC), and the application processor of the remote node. In general, the transaction time improves as the number of bytes of data in the message is reduced. This value is an appropriate figure of merit for control applications, where only small amounts of data are needed in each packet for the control function. The number of bytes per second is an indication of the data throughput between the application processors. The data throughput improves as the number of bytes in the message is increased, up to the limit for the LonTalk protocol, which is 228 bytes (160 bytes for the PLT-30). This value is an appropriate figure of merit for data communications applications, where large amounts of data need to be moved across the network, and where response time is less important. To evaluate data throughput where multiple packets of data need to be sent reliably and in sequence, see the section on *File Transfer Operations* below.

The number of packets transmitted on the network for each transaction depends on the service type. For unacknowledged service, the transaction is complete when the outgoing packet is sent. In this case, the number of packets sent to the MAC layer processor of the sending node is equal to the packet count for the run. If no errors occurred, the number of packets received by the remote node will also be equal to the packet count. Any discrepancy is due to a packet that was not received by the remote node, for example if the packet was corrupted by noise or attenuated below the receive threshold of the remote node. A corrupted packet usually will show up as a packet error on the remote node. If a signal carrier is detected by the sending node during the preamble of a packet, it will report a collision, and the MAC layer processor will retry the packet. This data link layer retry mechanism is independent of the transaction layer retry mechanism, which is executed by the network processor for acknowledged and request/response service only.

For acknowledged service, the number of packets transmitted on the network for each transaction depends on the number of nodes that need to acknowledge the message. Retries will be reported by the sending node if either an outgoing

message was lost, or one or more of the returned acknowledgments was lost. The number of packets sent to the MAC layer processor of the sending node should be equal to the packet count for the benchmark run plus the number of retries needed. The number of packets received by the sending node is equal to the total number of acknowledgments received from the remote node(s). Again, if a signal carrier is detected by any node during the preamble of a packet, it will report a collision and retry the packet at the MAC layer. For acknowledged service using multicast addressing in the absence of errors, when there are N remote nodes that are addressed, each transaction will consist of a total of N+1 packets, one packet for the outgoing message, and N acknowledgments.

In order to quantify the error rate from the results obtained from Bench, the type of messaging service must be considered.

For **unacknowledged** service the % error rate equals:

$$\frac{\text{total \# of packets - \# of packets addressed to remote node}}{\text{total \# of packets}} \times 100$$

For example, if you ran a benchmark for 10,000 packets and the remote node had 9,980 packets addressed to it at the end of the benchmark, the total error rate would be:

$$\frac{10{,}000 - 9{,}980}{10{,}000} \times 100 = 0.2\%$$

For **acknowledged** service the % error rate equals:

$$\frac{\text{total \# of transaction timeouts}}{\text{total \# of packets}} \times 100$$

For example, if you received 10 transaction timeouts for a benchmark that sent 1,000 packets, the total error rate would be:

$$\frac{10}{1{,}000} \times 100 = 1\%$$

In general, given that all other conditions are the same, the error rate for a benchmark using acknowledged service would be lower than that of one using unacknowledged service. This is because of the additional retry and transaction completion checking performed by the LonTalk protocol. The unacknowledged service is essentially a test of the physical layer power line transceiver, as there are no provisions for retries.

Table 4.1 Explanation of PLE-30 Benchmark Test Results

Parameter	Acceptable Result	Likely Cause of Unacceptable Result
Calculated % Error Rate	<10%	• Excessive power line noise • Other power line communication systems nearby • Transmitter and Receiver on different phases See *Solving Problems* in chapter 6.
Transaction Timeouts	0	No communication after 15 retries • High attenuation • Excessive power line noise • Other power line communication systems nearby • Transmitter and Receiver on different phases See *Solving Problems* in chapter 6.
Retries	•0 for unacknowledged •<10 for acknowledged	Retries at transport layer of protocol • High attenuation • Excessive power line noise • Other power line communication systems nearby • Transmitter and Receiver on different phases See *Solving Problems* in chapter 6.
Late ACK on Response	0	PLE-30 software error (contact Echelon)
Collisions Detected	0	Collisions at the physical layer • Excessive power line noise • Other power line communication systems nearby See *Solving Problems* in chapter 6.
Lost Messages	0	PLE-30 software error (contact Echelon)
Missed Messages	0	PLE-30 software error (contact Echelon)

effect, the device that needs to send data to the other device (either the host or the SLTA), first sends an ALERT command. The other device responds with an ACK command, and enters a tight loop waiting for data with interrupts disabled. The originating device can now send the data without concern for any possible overrun. Host architectures that can use the buffered protocol do not have this overhead. They simply receive data streams under interrupt control without any need for an ALERT/ACK handshake.

Network interfaces based on the various versions of the Microprocessor Interface Program (MIP) available from Echelon have different network interface protocols which in general have less overhead. When the network transceiver is a power line transceiver, the network interface protocol has a very minor effect on throughput since the network interface bit rate is so much greater than the bit rate on the medium.

Of course, for an application based on the Neuron Chip with no host processor, none of this network interface overhead is present, since the Neuron Chip application processor is integrated on the same chip as the communications protocol processors.

Host Processor

The performance of the host PC, the architecture of the network driver, and structure of the host application all have an impact on throughput. The host application supplied with the evaluation kit has been designed for maximum throughput, by exploiting the parallelism available with the three processors in the Neuron Chip. For an application based on the Neuron Chip with no host processor, the application processing is performed on a CPU dedicated to this purpose within the chip.

Power Line Factors Affecting Throughput

Commercial power line communication applications are often more difficult than residential applications because of the need to span multiple distribution panels or transformers. These additional impairments may result in an unacceptably high packet error rate, and may require the use of additional power line system solutions, including diagnostic equipment and segmentation/isolation devices.

Excessive error rates can be caused by excessive attenuation, excessive noise, or both. The following are examples of possible situations:

- Communication across different power phases. Sometimes the attenuation across two power phases is too high for reliable communications;
- Communication through a distribution transformer;
- Communication *through* an EMC filter. Many power strips have built-in filters that can block power line communications with devices that are not connected to the same strip;
- Poor ground connection (in the case of common mode operation);
- Excessive noise (usually localized to a few sources).

The two most difficult problems to overcome in power line communications are attenuation and noise. Of greatest concern is power line noise with frequency components at or near the communication frequency range of 9kHz-95kHz. The worst case communication scenario is when a noise source is present directly at the input of the receiver. Noise sources closer to the transmitter will be reduced or attenuated by the same factor as the transmitted signal and will thus have less of an effect on power line communications.

Attenuation is the difference between the signal level at the output of the power line transmitter and the level of that same signal at the input of the intended receiver. While attenuation is technically defined as the ratio of power levels, it will be referred to in this document as a voltage ratio. Attenuation will be defined as the ratio of the transmitted signal voltage (unloaded) to the voltage of that same signal at the receiver input. A voltage ratio is more convenient to measure since power measurements require knowledge of the circuit impedance, which in the case of the power line varies with both location and time.

In power line communications the attenuation of transmitted signals spans a wide range and is most conveniently denoted in decibels (dB), where voltage attenuation is defined in dB as $20\log_{10}(V_{transmit}/V_{receive})$. Thus 20dB of attenuation means that the signal was reduced by a factor of 10 by the time it arrived at the receiver, 40dB of attenuation corresponds to a factor of 100, 60dB a factor of 1000, and so on. The PLT-30 transceiver is capable of reliably communicating on a low noise line, such as a dedicated twisted wire pair, when the transmit signal is attenuated by 70dB, a factor greater than 3000. Thus a signal transmitted at roughly 10V peak-to-peak (p-p) may be received when reduced to less than 3.2mV p-p. Translated into distance, two PLT-30 transceivers have been demonstrated to communicate over 6100 meters (20,000 feet) of 22AWG (0.65mm) twisted pair wire, or 4500 meters (15,000 feet) of 24AWG (0.5mm) twisted wire pair, each end of which includes an AC coupled 100Ω termination.

On a typical AC or DC powered medium, significant signal loading and noise will be present. In these cases, the PLT-30 transceiver will provide reliable reception of signals attenuated up to 50 to 65dB. The actual physical distance over which the power line signal will propagate on a powered line is more difficult to calculate because attenuation is influenced as much by loading as it is by wire length. In practice, it may be necessary to actually measure the characteristics of the power mains.

To better understand the sources of attenuation in a power line network, it is helpful to look at a simplified model of a 220VAC power distribution network typical of a home or small commercial building having one power distribution panel. While many applications for power line communication employ different topologies, voltages, and wire types, this example serves to illustrate some of the key issues affecting the successful application of the PLT-30 transceiver.

Figure 5.4 shows schematically the path that a power line communication signal might traverse, starting from a wall socket and passing through the building's electrical wiring and circuit breaker panel, across power phases, and ultimately to another wall socket. Each socket in the power network may power a device that generates noise and loads the transmitted signal. For clarity, neutral and earth ground wires have not been shown connected to the wall sockets.

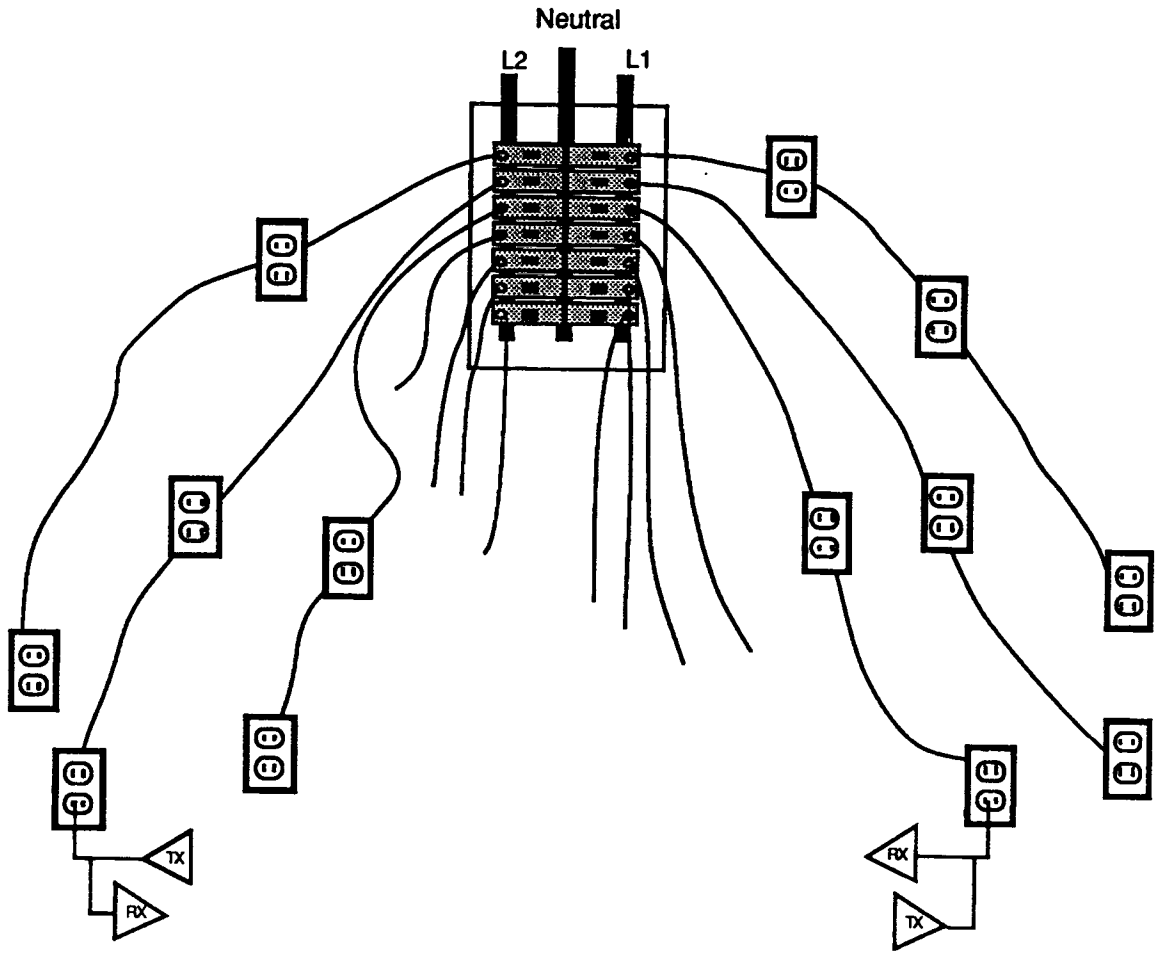


Figure 5.4 Power Distribution Model

Attenuation is most easily understood in terms of a voltage divider circuit formed between the output impedance of the transmitter, the impedance of the various power line circuit branches, and any loads present on the power line branch circuits. At the PLT-30 communication frequencies (9kHz - 95kHz) the significant impedances are due to the series inductance of the power wiring itself, capacitive loads between line and neutral, resistive loads between line and neutral, and the coupling between L1 and L2 which occurs due to natural parasitic inductance and capacitance between the two phases. If these distributed impedances are merged and treated as if a single frequency were being transmitted, the result is the model shown in figure 5.5.

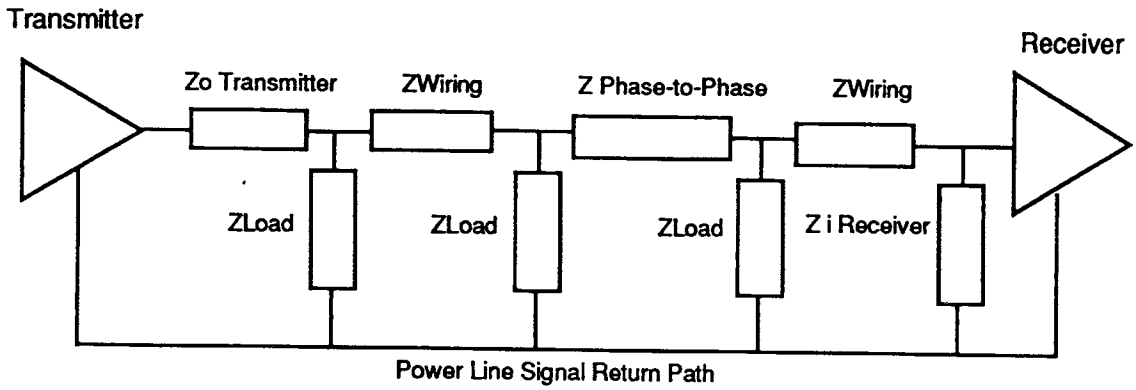


Figure 5.5 Power Line Attenuation Model

This model shows that minimizing the series impedances and maximizing the line-to-return path impedances will reduce the attenuation of a transmitted signal.