



STEP
TECHNICA

CUnet
Technical Guide
(For Network)

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Preface

This manual describes background information and technical briefings to help in building a network when using the CUnet. Be sure to read ***“CUnet Introduction Guide”*** before understanding this manual.

● Target Readers

This manual is for:

- Those who first build a CUnet
- Those who first use StepTechnica's various ICs to build a CUnet

● Prerequisites

This manual assumes that you are familiar with:

- Network technology
- Semiconductor products (especially microcontrollers and memory)

[Caution]

- **To users with *“CUnet User's Manual”* released before March, 2001**

Some terms in this manual have been changed to conform to International Standards.

- Some terms in this manual are different from those used on our website and in our product brochures. The brochure uses ordinary terms to help many people in various industries understand our products.

Please understand technical information on HLS Family and CUnet Family based on technical documents (manuals).

CONTENTS

| | |
|---|-----------|
| 1. Recommended Network | 1 |
| 2. Multi-drop Network | 1 |
| 3. Principle of Terminating Network Cables | 2 |
| 3.1 Signal Propagation Analogy | 2 |
| 3.2 Actual Electric Signal Propagation | 3 |
| 4. How to Connect Termination Resistor | 4 |
| 5. Prohibition of Stub Connection (Leader) | 5 |
| 6. Handling Unused Twisted Pairs | 6 |
| 7. Selecting Network Cable | 7 |
| 8. How to Select Differential Driver/Receiver Components | 8 |
| 8.1 Selecting Differential Driver | 8 |
| 8.2 Selecting Differential Receiver | 8 |
| 9. Using Pulse Transformer | 10 |
| 9.1 Advantages of Pulse Transformer | 10 |
| 9.2 Signal Transparency When Using Pulse Transformer | 11 |
| 10. Hot-swap | 12 |
| 11. How to Conduct Tests and Results | 13 |

Figures

| | | |
|------------------|---|-----------|
| Fig. 1.1 | Connection in Half-duplex Mode | 1 |
| Fig. 2.1 | Multi-drop Network in Half-duplex Mode | 1 |
| Fig. 3.1 | Propagation of Waves..... | 2 |
| Fig. 3.2 | Actual Electric Signal Propagation..... | 3 |
| Fig. 4.1 | Termination in Half-duplex Mode..... | 4 |
| Fig. 5.1 | Connection without Stub..... | 5 |
| Fig. 5.2 | Connection with Stub | 5 |
| Fig. 6.1 | Structure of Twisted Pairs and Handling Unused Twisted Pairs | 6 |
| Fig. 7.1 | Shielded Network Cable | 7 |
| Fig. 8.1 | How to Test Sensitivity and Regenerative Ability of Receiver..... | 9 |
| Fig. 9.1 | Pulse Transformer..... | 10 |
| Fig. 9.2 | Signal Transparency | 11 |
| Fig. 10.1 | Connection between Equipments Using Two Modular Connectors..... | 12 |
| Fig. 10.2 | Hot-swap of Individual Equipments Using Sub-circuit board..... | 12 |
| Fig. 11.1 | Noise Test in Half-duplex Mode | 13 |

1. Recommended Network

A CUnet is a system that operates in half-duplex communication mode.

When using the CUnet, the network connections shown in Figure 1 are recommended. TRX (driver/receiver) in the figure consists of pulse transformer and an RS-485 differential driver and receiver. This TRX provides electrical isolation between the CUnet-dedicated ICs (CUnet ICs) and the network cable(s).

Recommended network cables include Ethernet LAN network cables (10BASE-T, Category 3 or higher) and shielded network cables.

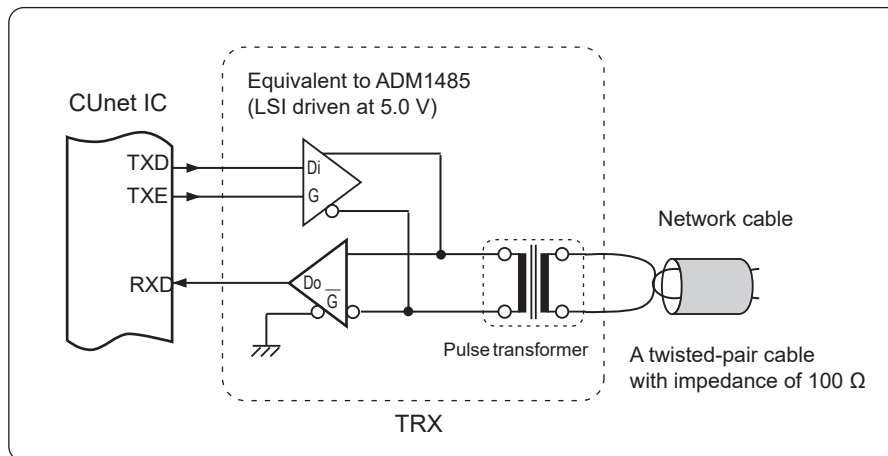


Fig. 1.1 Connection in Half-duplex Mode



Reference

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2. Multi-drop Network

In the CUnet, network cables between CUnet ICs can be connected on multi-drop network. Figure 2 shows the multi-drop network in half-duplex mode. The user must connect a termination resistor to the end (both ends) of these multi-drop-connected network cables to match impedance.

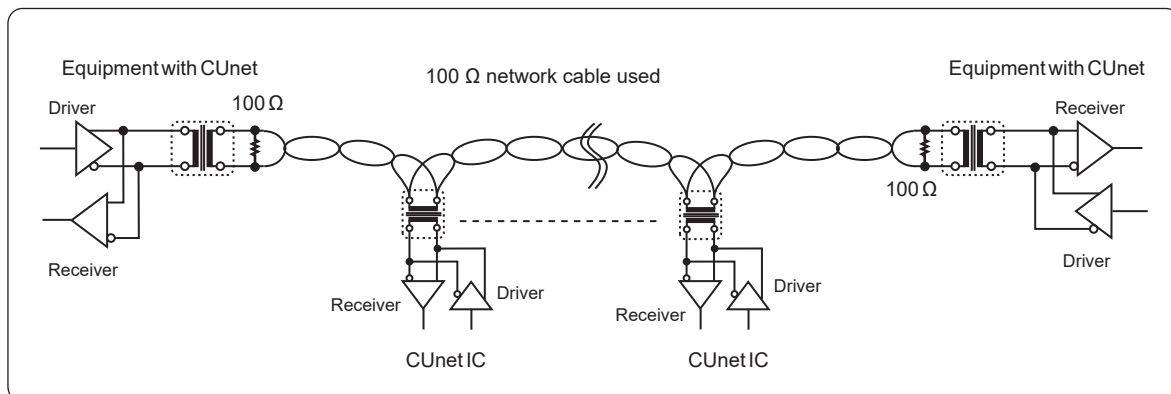


Fig. 2.1 Multi-drop Network in Half-duplex Mode

3. Principle of Terminating Network Cables

When using a network cable to build a CUnet network, the user must connect a termination resistor with the same impedance value as that of the network cable to both ends of the network cable.

The purpose of connecting termination resistor is to allow signals to be transmitted to the receiving system without interference, such as waveform breakdown and waveform disappearance.

The principle is shown below.

3.1 Signal Propagation Analogy

Figure 3.1 illustrates signal propagation using the analogy of ripples spreading across water.

- (1) The propagation of digital signals is compared to ripples spreading across water.
- (2) When the waves hit obstacles, they are reflected to return.
- (3) If the waves do not hit an obstacle, they never return.

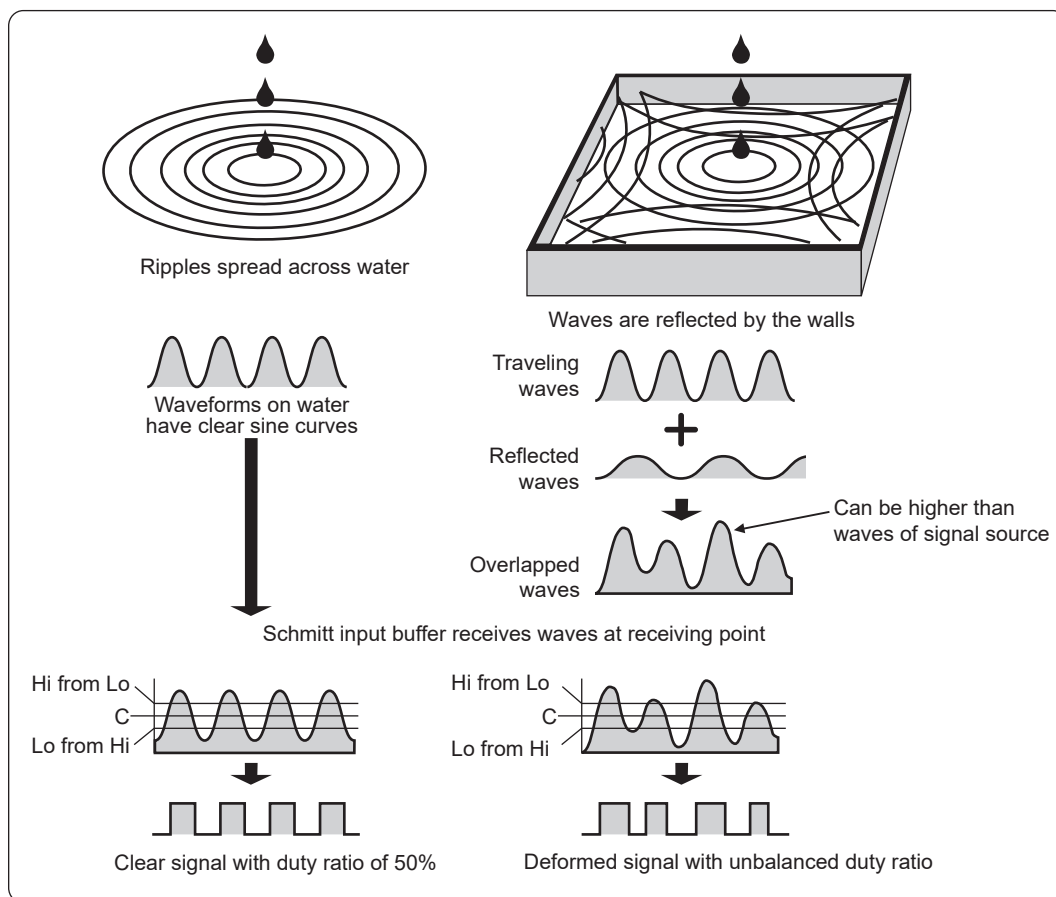


Fig. 3.1 Propagation of Waves

3.2 Actual Electric Signal Propagation

Figure 3.2 shows actual electric signal propagation.

- (1) A network cable can be compared to water with the same load (weight) impedance viewed from any direction. The network cable with an impedance of $100\ \Omega$ has an impedance of $100\ \Omega$ viewed from any direction.
- (2) If the end of the network cable is open, the network cable is essentially the same as being connected to an infinitely large resistor, just like a large wall. When a propagated signal hits the infinite large resistor, it is reflected.
- (3) If the network cable is apparently endless, signal reflection does not occur.

The network cable can be connected to a resistor (termination resistor) with the same value as the impedance of the network cable to create an electrical environment equivalent to an endless cable. For these reasons, in the network using CUnet network cables, connect the termination resistor to the end of the network cable.

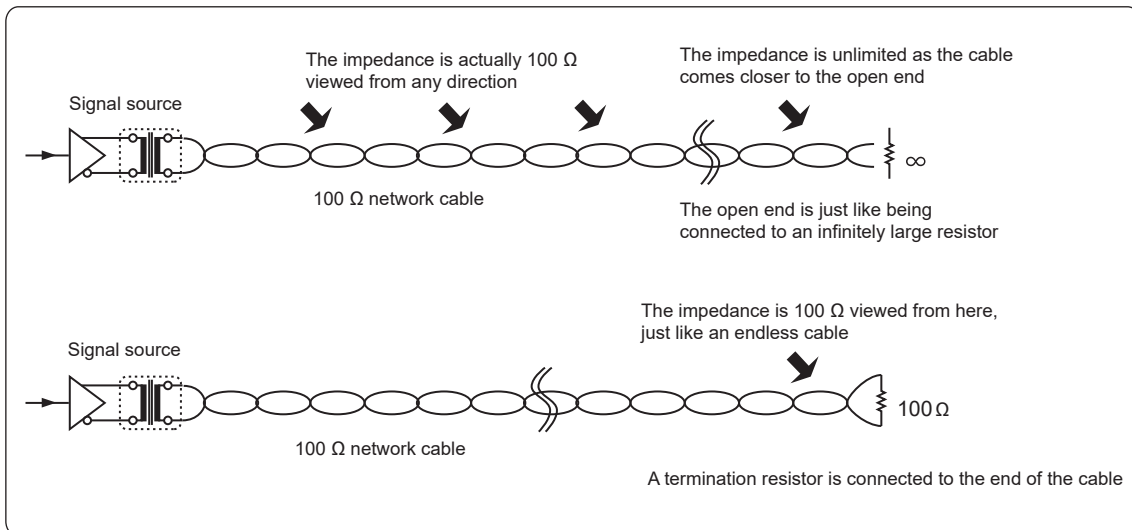


Fig. 3.2 Actual Electric Signal Propagation

Reference

Impedance is usually kept consistent across the entire network, which is called “impedance matching”. Conversely, impedance may be partially inconsistent, which is called “impedance mismatch”.

4. How to Connect Termination Resistor

This section describes how to connect a termination resistor specifically.

Figure 4.1 shows the connection of the termination resistor between the equipment with CUnet ICs.

Connect the termination resistor to both ends of the cable. As shown in Figure 4.1, do not connect the termination resistor to the terminal that is in the intermediate position (the halfway position in the network cable) of a multi-drop network.

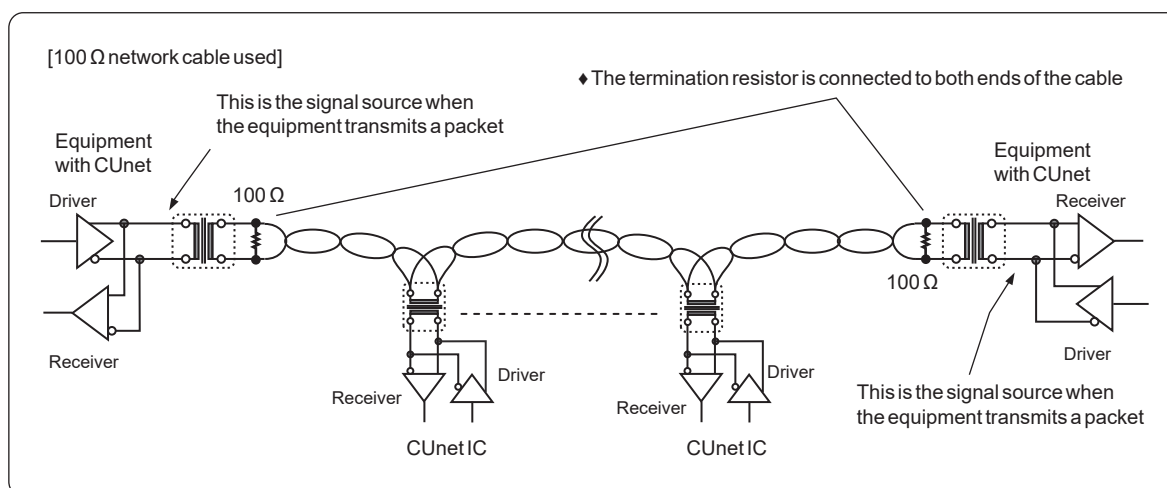


Fig. 4.1 Termination in Half-duplex Mode

5. Prohibition of Stub Connection (Leader)

When using network cables in the CUnet network, do not make any multipoint connection between the cables with a stub (leader) (Fig. 5.2). The reason is explained below.

The electrical characteristics are different between the connection without a stub (Fig. 5.1) and the multipoint connection with a stub (Fig. 5.2). The connection without a stub (Fig. 5.1) can match impedance, whereas the multipoint connection with a stub (Fig. 5.2) causes impedance mismatching at the stub branch. Like ripples spreading across water, the multipoint connection with a stub (Fig. 5.2) causes signal reflection and loss of propagation energy. Therefore, the multipoint connection with a stub (Fig. 5.2) is not suitable for the network using CUnet network cables.

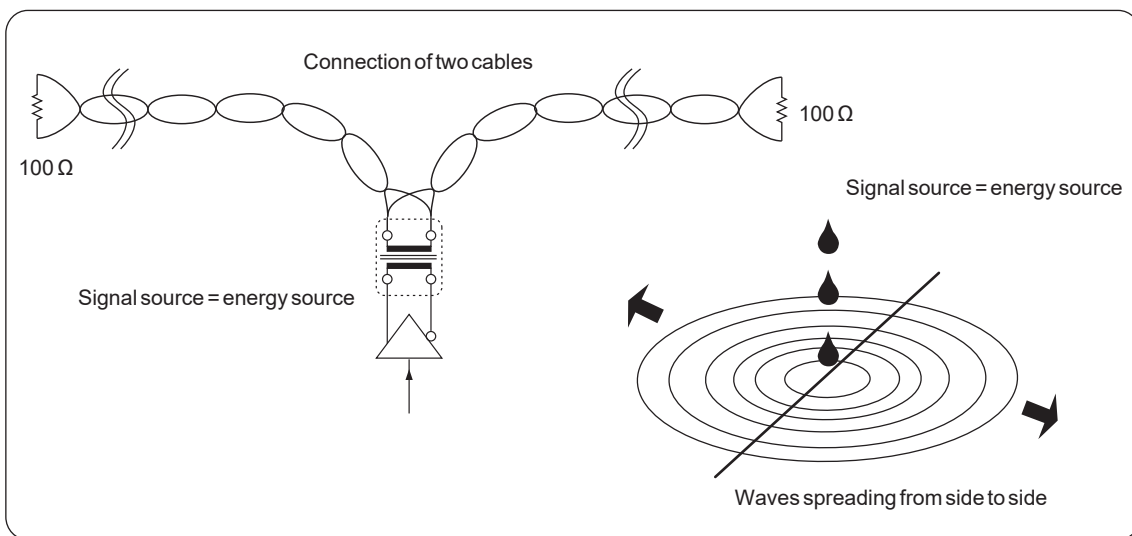


Fig. 5.1 Connection without Stub

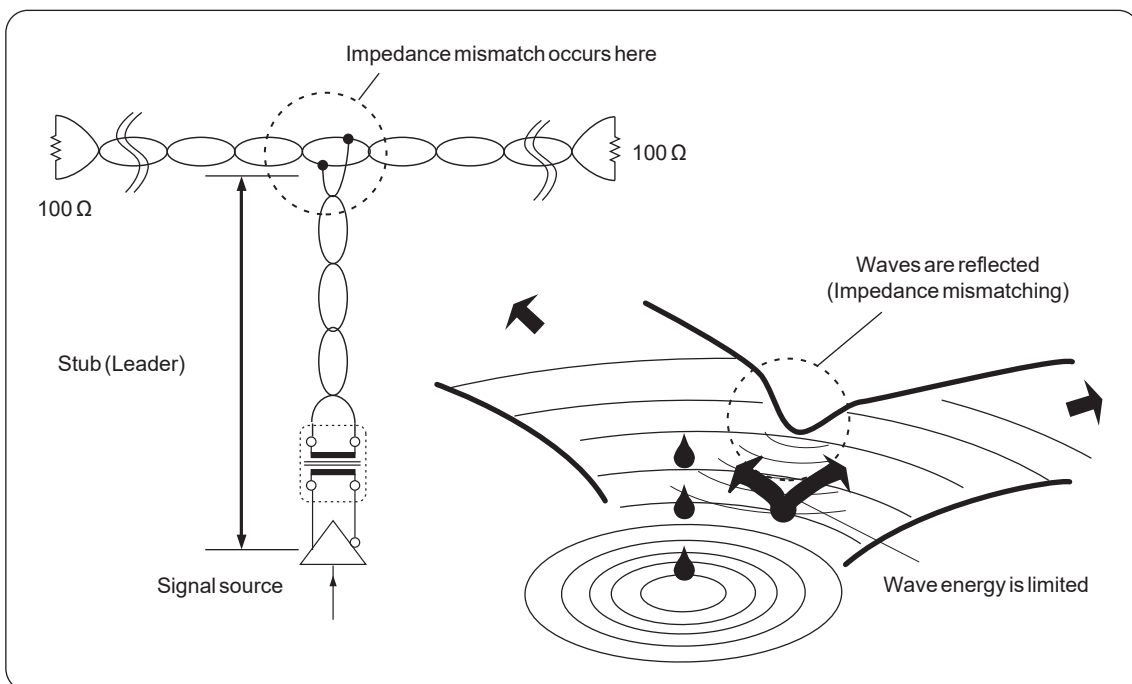


Fig. 5.2 Connection with Stub

6. Handling Unused Twisted Pairs

In the network cable composed of multiple twisted pairs, each twisted pair has different twisting pitches (Fig. 6.1), which prevents interference (crosstalk) between signals propagated between twisted pairs.

When using a network cable composed of multiple twisted pairs in the CUnet, do not connect the unused twisted pairs and twisted pairs in parallel (Fig. 6.1).

Operational suitability tests conducted by StepTechnica show that handling unused twisted pairs by methods other than parallel connection (keeping wires open or grounding them) has no adverse effect on signals propagating through twisted pairs.

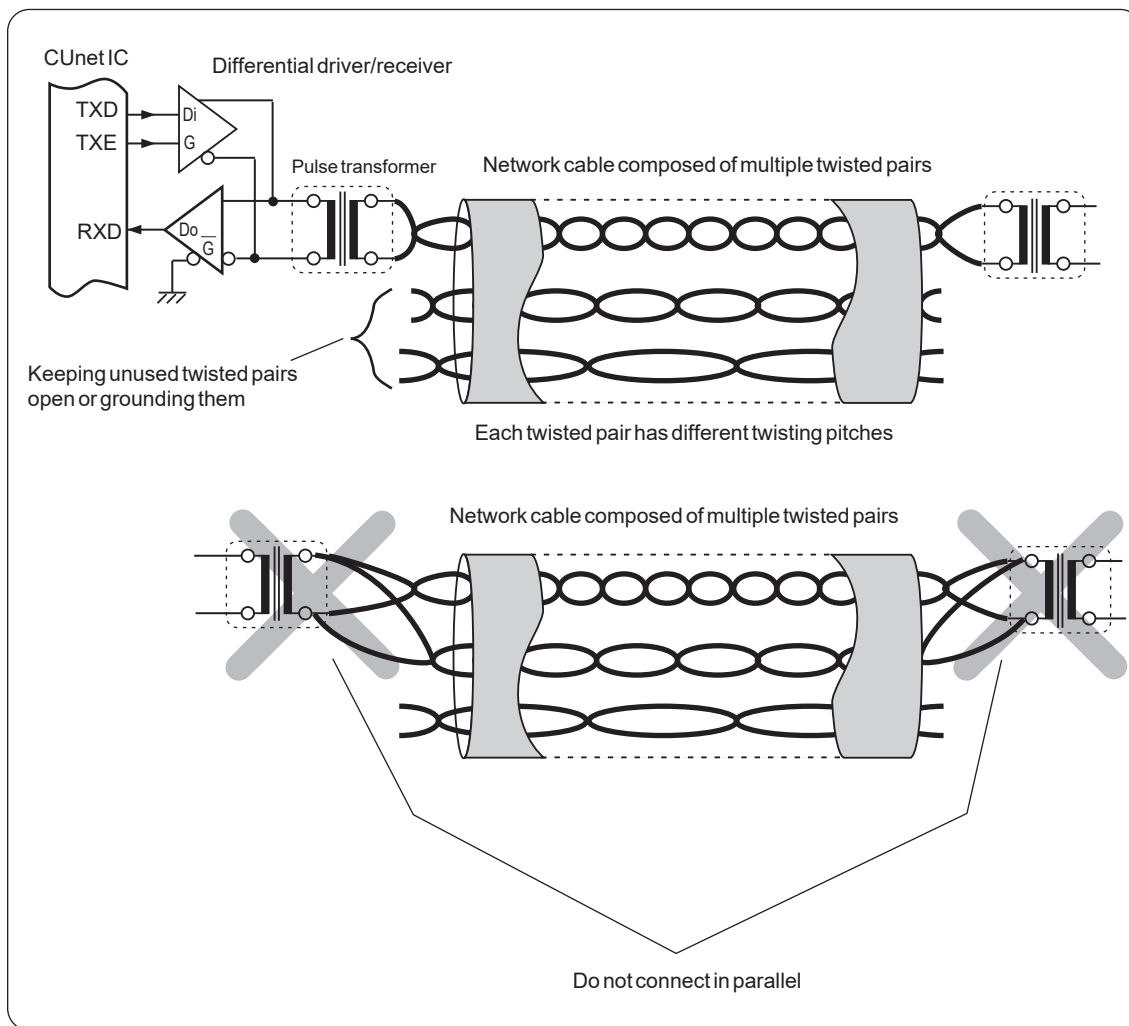


Fig. 6.1 Structure of Twisted Pairs and Handling Unused Twisted Pairs

Reference

The propagation speed of the signal in the twisted pair varies slightly depending on twisting pitch (because the effective cable lengths are different). Parallel connection of twisted pairs can cause signals with a time difference to be mixed at the terminal point, causing transmission failure.

7. Selecting Network Cable

Various electric wires (cables) are available to feed power and transmit very small signals, depending on the purpose.

Generally, an electric wire with excellent signal transmission performance, with smaller distribution quantity, faster signal propagation, slower signal fade, and less crosstalk (interference between signals) is used as a “network cable”. A network cable with these features inevitably has uniform impedance (refer to “**3.2 Actual Electric Signal Propagation**”).

A network cable is usually used in the CUnet. Select the network cable suitable for the user system by considering factors other than signal transmission performance, such as workability and simplicity of setting up the cable to connectors, shielding, fire resistance, and strength, etc.



Reference

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In the CUnet, a network with a relatively short cables (about 10 m) requires less emphasis on signal transmission performance. Signal transmission performance becomes more important as the cable length gets longer. From this respect, StepTechnica recommends using Ethernet LAN network cable (10BASE-T, Category 3 or higher) and shielded network cables. The reason for using shielded network cable is to prevent interference from external noise (static electricity) (Fig. 7.1). Another reason is to prevent signal emission (Fig. 7.1).

Single-point grounding is generally preferable for shielding. However, the user system environment where single-point grounding can be used is rare. Therefore, select the most effective grounding (such as one-side grounding, both-sides grounding, midpoint grounding, or non-grounding) according to the user’s environment.

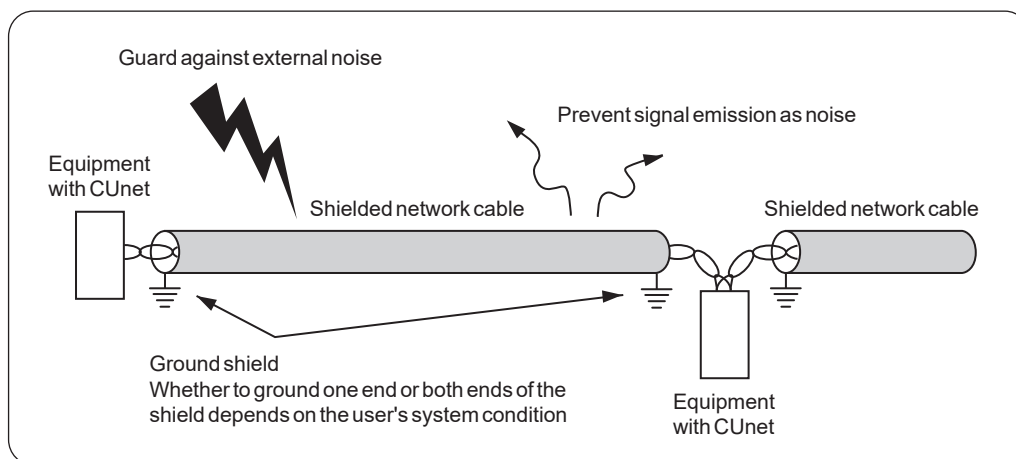


Fig. 7.1 Shielded Network Cable



Reference

The “management function of network” in the CUnet IC are useful in determining the operability of the CUnet. For details, refer to the each “**CUnet IC Manual**”.

8. How to Select Differential Driver/Receiver Components

This section describes how to select RS-485 differential driver/receiver components used in the network.

8.1 Selecting Differential Driver

The following conditions must be satisfied when selecting the differential driver used in the CUnet.

(1) **Driver respons capability based on baud rate**

For example, with a baud rate of 12 Mbps, the packet in the CUnet consists of 6-MHz and 3-MHz frequency component signals. Therefore, when a normal clock with a high-frequency component (6 MHz) (a square wave or a sine wave signal with a duty ratio of 50%) is input to the input pin of the driver, the output of a differential driver must have the capability to be driven similarly to the normal clock with a duty ratio of 50%.

(2) **Capability to drive cable impedance load**

If the driver operates on a power supply of 5.0 V, it must have the capability to drive the network cable with an impedance of 100 Ω at ± 50 mA ($5.0 \text{ V} \div 100 \Omega$) or more.

(3) **Thermal shutdown function**

If the driver is enabled and a drive signal stops when a system failure or an unexpected error occurs, the primary coil of the pulse transformer works as a simple copper wire and becomes equivalent to a DC load of 0 Ω (short-circuited). At this time, the maximum current flows continuously from the differential driver and the differential driver components produce heat. Because of this, conventional differential drivers have a thermal shutdown function.



Caution

The cable lengths enabling signal transmission described in “*CUnet Introduction Guide*” and each “*CUnet IC Manual*” are based on our experimental measurements using differential driver components that operate on a power supply of 5.0 V. The output of differential driver components operating on a power supply of 5.0 V is 5.0 V_{p-p}, whereas the output of differential driver components operating on a power supply of 3.3 V is 3.3 V_{p-p}. Thus, the energy to supply signals to the network cables varies depending on the difference in the drive power supply of the differential driver components. For this reason, cable lengths enabling signal transmission are considered to vary depending on the energy to be supplied.

8.2 Selecting Differential Receiver

The differential receiver used in the CUnet must meet the following requirements:

- (1) Must have sufficient response capability to signals corresponding to the baud rate
- (2) Must have sufficient receiver sensitivity to signals mentioned above in (1)

If the receiver sensitivity and response capability to high frequency are insufficient in the differential receiver, the values for network cable lengths described in “*CUnet Introduction Guide*” and each “*Manual*” of the CUnet cannot be expected.



Reference

Our experience shows that there are some products where sufficient sensitivity and regenerative ability as described in the manuals or specification sheets provided by manufacturers cannot be achieved. (The receiver used in the following two examples is described as “12 Mbps capable” in the manual.)

Example 1: RS-485 receiver sensitivity of 200 mVp-p. Manufacturer’s manual described the “receiver sensitivity as 200 mVp-p”. However, only frequency component signals of less than 1 MHz could obtain this receiver sensitivity.

Example 2: Some products from manufacturer B require an input sensitivity of 3.0 Vp-p to be able to regenerate a normal clock with a duty ratio of 50% when a 12 MHz normal clock is input.

Thus, when selecting a differential receiver, StepTechnica recommends the user conduct simple experiments (Fig. 8.1) for practical use of the CUnet. For example, when selecting a baud rate of 12 Mbps consisting of 6-MHz and 3-MHz frequency component signals, connect the following signals to input pins of the differential receiver.

- (1) 6 MHz normal clock of less than 200 mVp-p (a square wave and a sine wave signal with a duty ratio of 50%)
- (2) 12 MHz normal clock of less than 500 mVp-p (a square wave and a sine wave signal with a duty ratio of 50%)

After these clocks are input, observe whether the differential receiver output a logic signal (a square wave) with a duty ratio of 50% (giving a slight duty collapse of less than 5%).

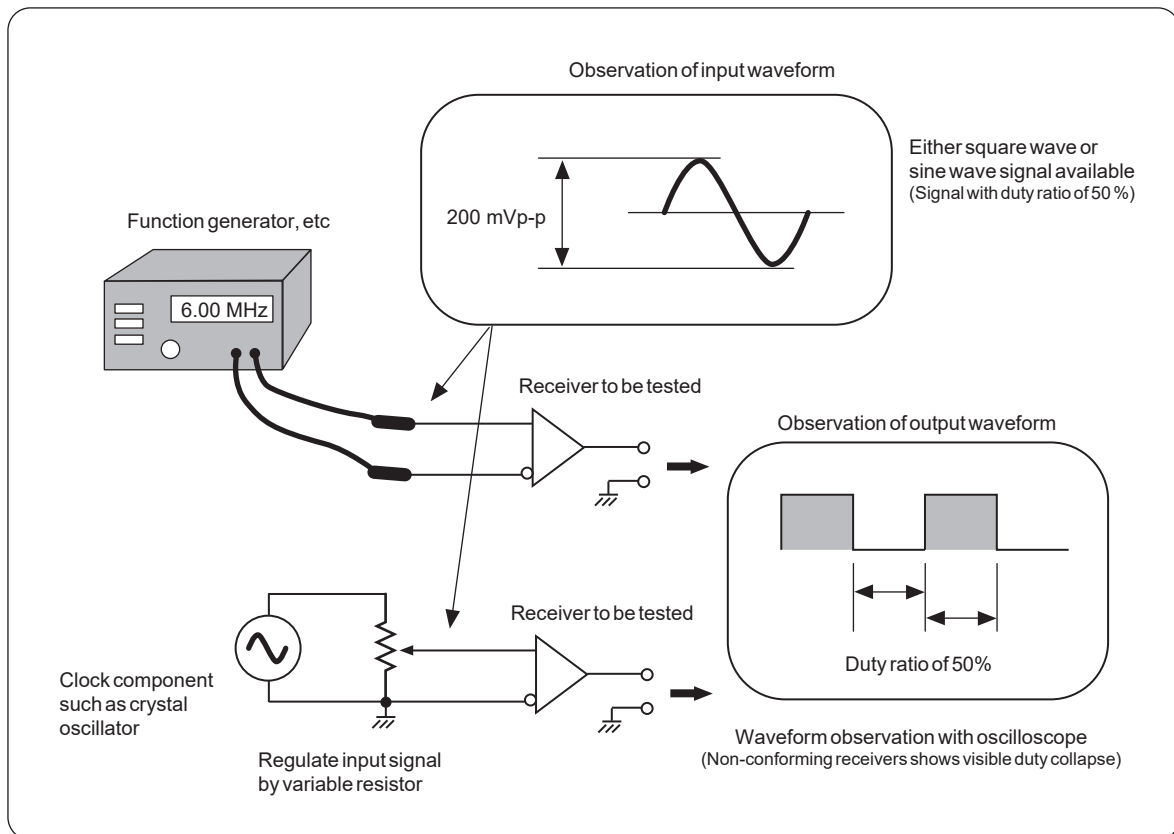


Fig. 8.1 How to Test Sensitivity and Regenerative Ability of Receiver

9. Using Pulse Transformer

A pulse transformer should be used in the CUnet network. This section describes the advantages in using a pulse transformer and the transparency of signals.

9.1 Advantages of Pulse Transformer

Using a pulse transformer in the CUnet offers the following three advantages:

- (1) Electronic components (such as circuit boards) containing CUnet ICs can be electrically insulated from the network (Fig. 9.1).
- (2) If there is no pulse transformer and a failure occurs where the driver continuously drives the network, all signal transmissions will cease, forcing the entire user system to stop.
If used, a pulse transformer never allows DC components to pass. Therefore, only inoperable equipments fail to transmit signals, having no adverse effect on other equipments.
- (3) If external noise enters the network, a pulse transformer prevents it from reaching receiver components directly. This results in an increased ability to guard against the external noise.

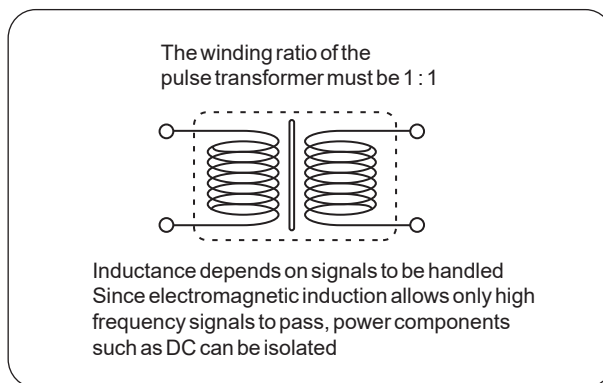


Fig. 9.1 Pulse Transformer



Reference

Our recommended pulse transformer is suitable for CUnet baud rates of 12 Mbps, 6 Mbps, and 3 Mbps.

To get our recommended components, visit our Web site.

<https://www.steptechnica.com/en/>



Caution

When using the CUnet at baud rates of 12 Mbps or more or 3 Mbps or less, the user should select a suitable pulse transformer.

9.2 Signal Transparency When Using Pulse Transformer

When a pulse transformer suitable for baud rates is used, it will be signal transparent. Figure 9.2 shows a pulse transformer to be multi-drop-connected in the CUnet with signal transparency. When connecting a termination resistor described in item “4. How to Connect Termination Resistor”, resistors may be placed both before and after signals pass through the pulse transformer, so that the relationship between the pulse transformer and the termination resistor can be identified (Fig. 9.2).

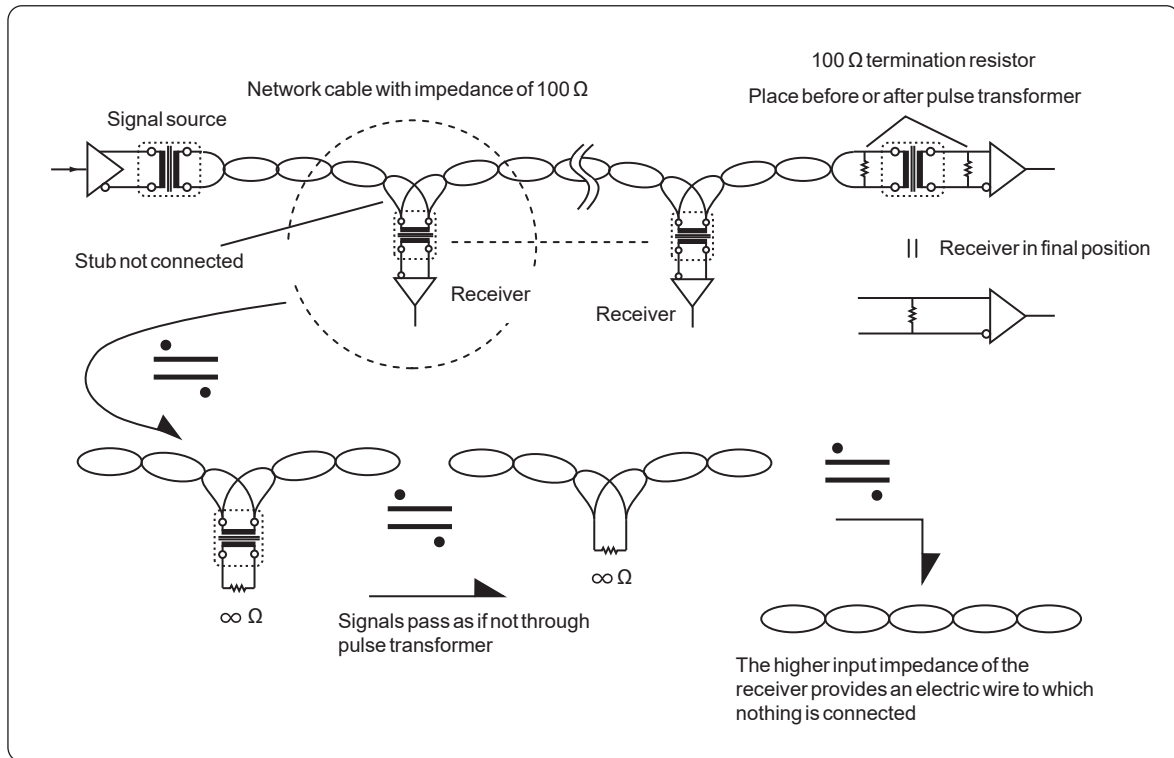


Fig. 9.2 Signal Transparency

Reference

The pulse transformer need not be used for user systems that do not require the advantages described in item “9.1 Advantages of Pulse Transformer”. The CUnet ICs operate correctly regardless of whether a pulse transformer is used or not.

10. Hot-swap

The user system may require hot-swapping of the equipment with CUnet. In this case, some preventive measures must be taken to prevent disconnecting the multi-drop-connected lines in the middle of the network. For example, Figure 10.1 and 10.2 show connection using two modular connectors.

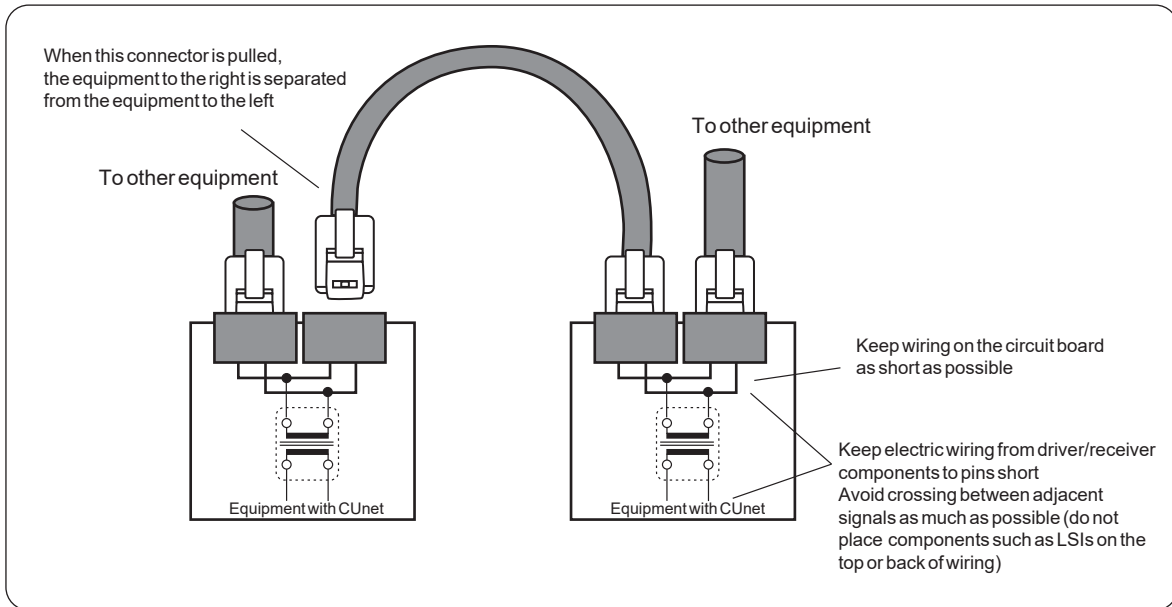


Fig. 10.1 Connection between Equipments Using Two Modular Connectors

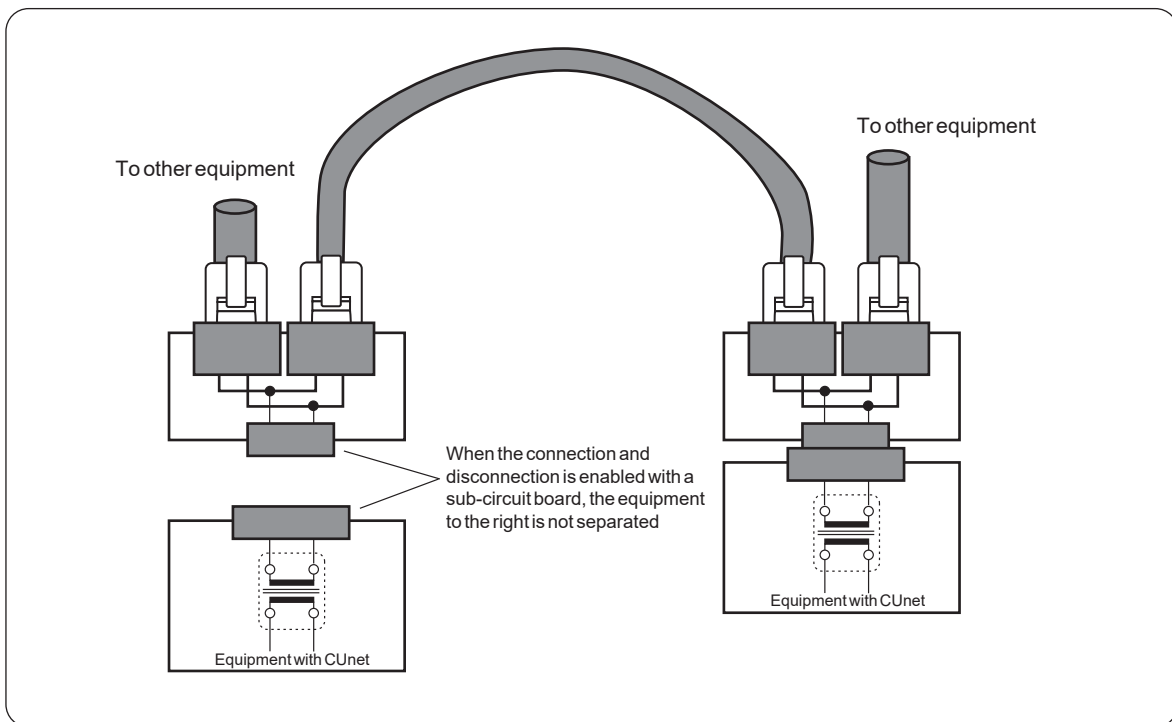


Fig. 10.2 Hot-swap of Individual Equipments Using Sub-circuit board

11. How to Conduct Tests and Results

Noise from environments surrounding a signal transmission system (such as noise from other factory machines) may result in malfunctions or damage to the signal transmission system used for control and measurement.

In this case, antinoise measures are taken at the design stage of a user equipment containing IC components. However, they provide only partial prevention, because antinoise measures can only be taken to the point that does not affect signal propagation in cables and noise from surroundings cannot be removed completely. Unblocked noise acts like a normal signal and is mixed with propagating signals, resulting in garbage data or malfunctions.

Assuming this situation, StepTechnica conducted noise tests as shown in Figure 11.1 by injecting signal-level noise into network cables. This is a severe test. StepTechnica carried out more than 48 hours of continuous operation tests on the CUnet at each baud rate (by injecting noise 40 times per second for 48 hours) and confirmed that neither garbage data nor malfunctions occurs in the CUnet.



Reference

For details of noise tests, refer to **“6. Data Quality Assurance”** in **“CUnet Introduction Guide”**.

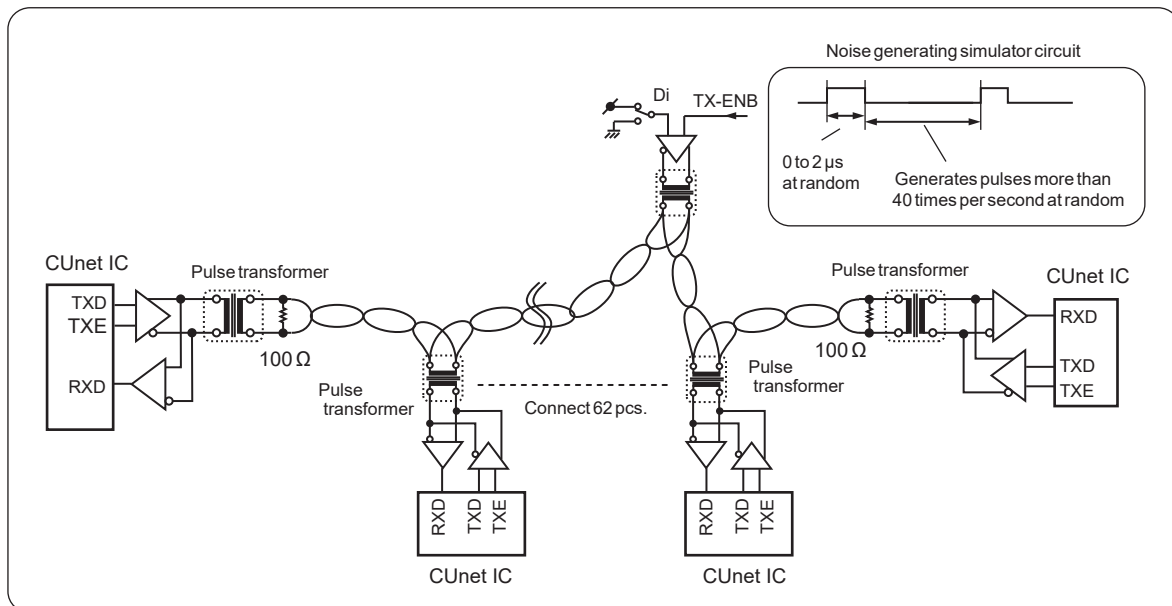


Fig. 11.1 Noise Test in Half-duplex Mode

Revision History

| Version No. | Date | Page | Contents |
|-------------|------------|------|--|
| 1.3 | June, 2008 | | |
| 1.4 | June, 2023 | 5 | Fig. 5.2. Modification of stub (leader line) section |
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CUnet **Technical Guide (For Network)**

Document No.: STD_CUTGN_V1.2E

Issued: June 2023