PicoScope 2204A
10 MHz oscilloscope

User Guide

How to use the oscilloscope for trouble shooting on Danfoss Electronics Controls and systems.

Attention

To avoid injury or damage of the Picoscope 2204A or devices connected to the oscilloscope, the equipment should only be used by Danfoss employees with the technical skills that are required for a correct and safe use of the equipment.

Read the safety instructions in the PicoScope USB Oscilloscope QUICK START GUIDE

picoscope-2000-serie
s-quick-start-guide.p(

To prevent damage to the PC that is connected to the oscilloscope, it's strongly recommended to use a Galvanically isolated USB 2.0 Adaptor between the PC and the oscilloscope.

If you don't use a Galvanically isolated USB adaptor, do never use the oscilloscope while your PC is connected to 115/230 V main supply (during charging or if permanently connected).

Insert the USB 2.0 Isolator in a USB port of the PC, and connect the Picoscope 2204A USB cable to the female port of the adaptor. Windows driver installation will fail, but that will be corrected on the software installation.

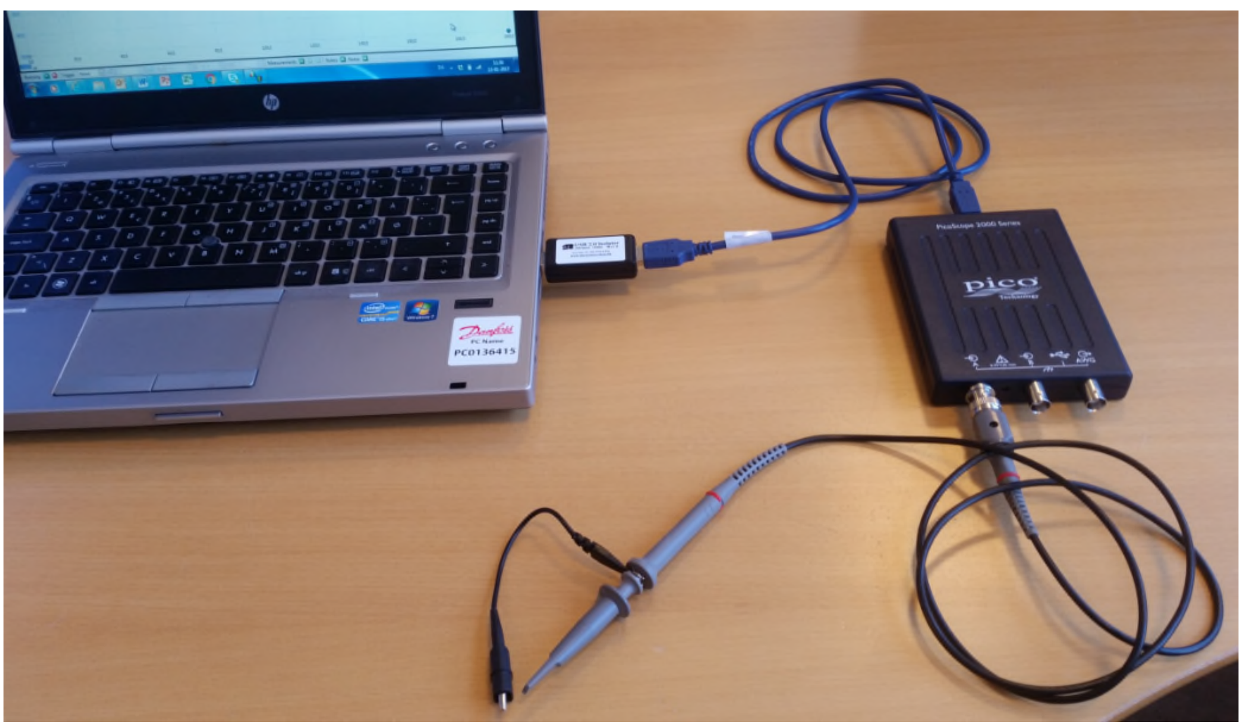


Table of Contents

Installing the PicoScope software 4
Start-up setting files. 5
Calibration of the Probes. 7
Measurements on LON- and Mod-bus installations. 8
Proper bus installation. 10
RS 485 bus communication. 11
Examples of Proper Networks. 15
Examples of Improper Networks. 17
Examples of good and bad signals. 20
Saving measurements (screen shoots) 25

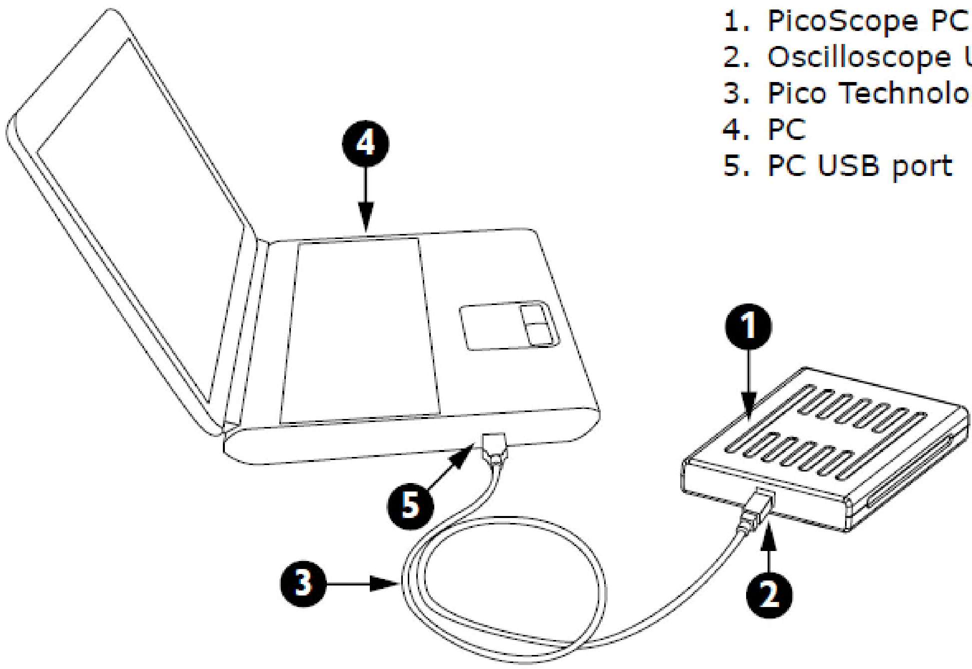
Installing the PicoScope software

1. Insert the Pico software disk into your CD drive. It should start automatically. If it does not, go to **My Computer** (or **This PC** for Windows 8 and 10) and run the Pico CD. Alternatively, the software can also be downloaded from: **www.picotech.com/downloads**

2. Select the appropriate language.

3. Follow the on-screen instructions to install the PicoScope software.

4. Connect the oscilloscope to your PC using the USB cable supplied, as shown in the connection diagram below.



1. PicoScope PC Oscilloscope
2. Oscilloscope USB port
3. Pico Technology USB cable
4. PC
5. PC USB port

5. Windows may automatically display a **New Hardware Found** notification. Follow any instructions shown. Note: If Windows asks to connect to **Windows Update**, select **No**.

6. Select **PicoScope 6** from the Windows **Start** menu.

7. If your oscilloscope requires a probe, connect one to channel A first. Touching the tip of the probe should result in a small 50 Hz or 60 Hz signal showing in the PicoScope window.

(Start-up) setting files.

To start the Oscilloscope SW, click the Picoscope icon on your desktop. 

From the Picoscope oscilloscope program it's possible to select and switch between different setting files, depending on the measurements that must be performed.

3 (start-up) setting files have been created for the most common purposes

1. Calibration of probes
   (file: PicoScope 2204A Probe calibration – Start-up setting file.pssettings)
   

2. Measurements on LON bus signals
   (file: PicoScope 2204A LON-bus measurements – Start-up setting file.pssettings)
   

3. Measurements on MOD bus signals
   (file: PicoScope 2204A MOD-bus measurements – Start-up setting file.pssettings)
   

The files must be stored on the PC with the PicoScope SW. Create a "Setting file folder"

Load or switch between the different setting files.

1. In the Top menu click "File" and choose open.
2. In your "setting file folder", find the .pssetting file with the settings you need.
3. Click the setting file and the Oscilloscope will "re-start" with the new settings

Create your own setting files.

To create your own library of different setting files do as follows

1. In the Top menu click "File" and choose "Start-up settings"
2. Choose "Save settings as"
3. Name the file and save it in your "Setting file folder".

General use of the Picoscope.

The General use of the PicoScope 2204 is described in detail in the PicoScope 6 PC Oscilloscope Software – User's Guide.

picoscope-6-users-guide-en.pdf

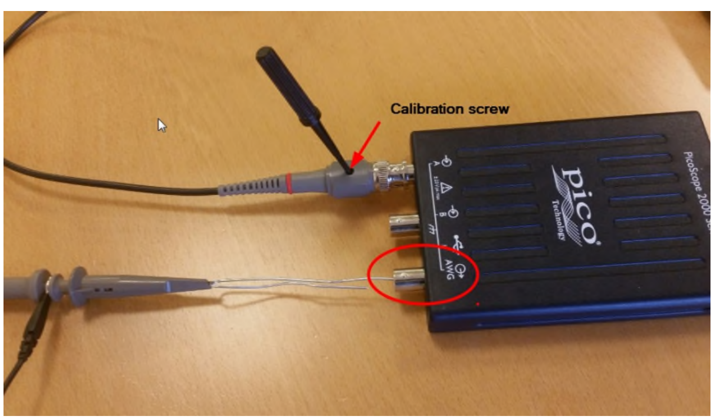
Calibration of the Probes.

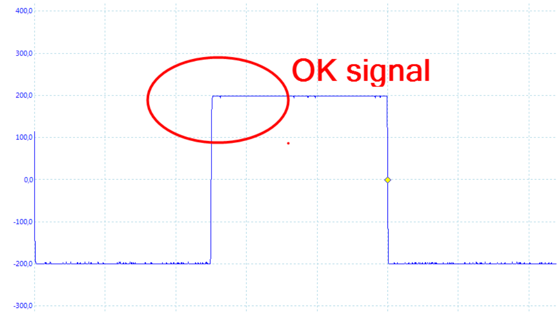
To ensure a correct shape of the measured signal, it might be necessary to calibrate the probes.

To calibrate the probes follow the instructions below.

1. Connect the Picoscope as shown on the picture below. Remember to use the USB isolator.

2. To start the calibration procedure, close all open Pico sessions and click the file "PicoScope 2204A Probe calibration – Start-up setting file.pssettings" to open the PicoScope SW.
3. A test signal for probe calibration is available on the AWG output of the Picoscope (1kHz, +/- 2V). **Attention: Set Red Glideswitch (X1 – X10) on the probe to X10.**
4. Insert a metal clips in the middle female pin of the AWG connector, and Snap-On the probe to the clips as shown on the picture below. If there is too much noise on the signal, then connect the black crocodile clips to the outer metal cap of the "AWG" or the "Input B" connector.
5. Adjust the calibration screw on the probe until the signal scape is a proper square curve. Use the calibration screwdriver that is included in the Picoscope package.
6. Calibration of the probe is done, and will normally not require re-calibration.
   Set Red Glideswitch (X1 – X10) on the probe to X1.





Measurements on LON- and Mod-bus installations.

To make measurements of LON- or MOD-bus signal quality, follow this procedure.

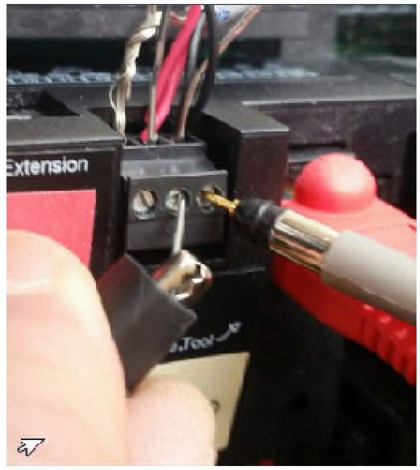
1. Connect the Picoscope as shown on the picture below. Remember to use the USB isolator.

2. For measurements on LON-bus signals, close all open Pico sessions and click the file “PicoScope 2204A LON-bus measurements – Start-up setting file.pssettings” to open the PicoScope SW.

3. For measurements on MOD-bus signals, close all open Pico sessions and Click the file “PicoScope 2204A MOD-bus measurements – Start-up setting file” to open the PicoScope SW.

4. Measurements should be made at least at the first and the last controller on the LON-/MOD-bus.
5. The signal must be measured between the A and B terminals of the bus connector.
6. The safest way to measure is to mount e.g 2 cuttings of a paperclip in the A and B terminal and Snap-On the probe to these. Alternatively, clip a few centimeters stiff wire (e.g cutting of a paperclip) in the crocodile clips, uncap the probe and measure directly

on the terminal A and B shrews.



Proper bus installation.

To ensure a proper wiring of the bus installation, it’s recommended to follow the advice in the instruction “Data communication between ADAP-KOOL controls”

Data com between
ADAP-KOOL controls

RS 485 bus communication.

MOD- and LON bus communication between ADAP-KOOL controls are based on RS-485 serial communication.

The description below is copied from a MAXIM application note, and describe in general the RS 485 serial communication.

RS-485 is designed to be a balanced system. Simply put, this means there are two wires, other than ground, that are used to transmit the signal.

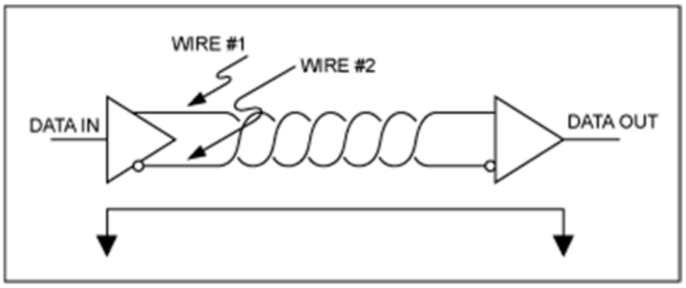


Figure 1. A balanced system uses two wires, other than ground, to transmit data.

The system is called balanced, because the signal on one wire is ideally the exact opposite of the signal on the second wire. In other words, if one wire is transmitting a high, the other wire will be transmitting a low, and vice versa. See **Figure 2**.

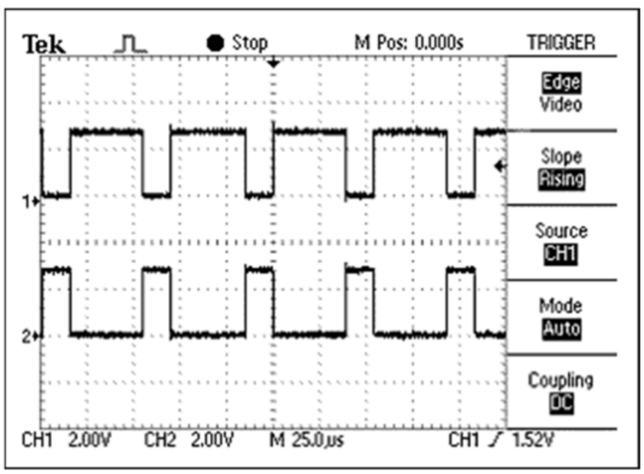


Figure 2. The signals on the two wires of a balanced system are ideally opposite.

Although RS-485 can be successfully transmitted using multiple types of media, it should be used with wiring commonly called "twisted pair."

What Is Twisted Pair, and Why Is It Used?
As its name implies, a twisted pair is simply a pair of wires of equal length and twisted together. Using an RS-485-compliant transmitter with twisted-pair wire reduces two major sources of problems for designers of high-speed long-distance networks: radiated EMI and received EMI.

Radiated EMI
As shown in **Figure 3**, high-frequency components are present whenever fast edges are used

in transmitting information. These fast edges are necessary at the higher data rates at which RS-485 is capable of transmitting.

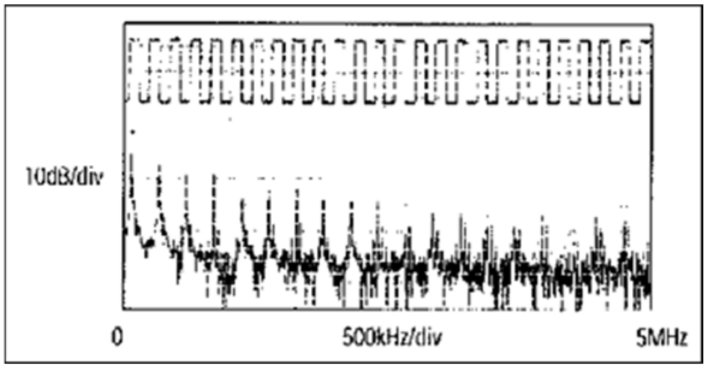


Figure 3. Waveform of a 125kHz square wave and its FFT plot.

The resultant high-frequency components of these fast edges coupled with long wires can radiate EMI. A balanced system used with twisted-pair wire reduces this effect by making the system an inefficient radiator. It works on a very simple principle: as the signals on the wires are equal but opposite, the radiated signals from each wire will also tend to be equal but opposite. This has the effect of canceling each other, meaning that there is no net radiated EMI. However, this result is based on the assumption that the wires are exactly the same length and in exactly the same location. Because it is impossible to have two wires in the same location at the same time, the wires should be positioned as close to each other as possible. Twisting the wires so there is a finite distance between the two wires helps counteract any remaining EMI.

Received EMI

Received EMI is basically the same problem as radiated EMI but in reverse. The wiring used in an RS-485 system will also act as an antenna that receives unwanted signals. These unwanted signals could distort the desired signals, which, if bad enough, can cause data errors. For the same reason that twisted-pair wire helps prevent radiated EMI, it also helps reduce the effects of received EMI. Because the two wires are close together and twisted, the noise received on one wire will tend to be the same as that received on the second wire. This type of noise is referred to as "common-mode noise." As RS-485 receivers are designed to look for signals that are the opposite of each other, they can easily reject noise that is common to both.

Characteristic Impedance of Twisted-Pair Wire

Depending on the geometry of the cable and the materials used in the insulation, twisted-pair wire will have a "characteristic impedance" associated with it that is usually specified by its manufacturer. The RS-485 specification recommends, but does not specifically dictate, that this characteristic impedance be 120Ω. Recommending this impedance is necessary to calculate worst-case loading and common-mode voltage ranges given in the RS-485 specification. The specification probably does not dictate this impedance in the interest of flexibility. If for some reason 120Ω cable cannot be used, it is recommended that the worst-case loading (the number of transmitters and receivers that can be used) and worst-case common-mode voltage ranges be recalculated to make sure that the system under design will work. The industry-standard publication TSB89, *Application Guidelines for TIA-EIA-485-A*,[1] has a section specifically devoted to those calculations.

Number of Twisted Pairs per Transmitter

Now that the required type of wire is understood, one can ask, how many twisted pairs can a transmitter drive? The short answer is: exactly one. Although it is possible for a transmitter to drive more than one twisted pair under certain circumstances, this is not the intent of the specification.

Termination Resistors
Because of the high frequencies and the distances involved, proper attention must be paid to transmission-line effects. A thorough discussion of transmission-line effects and proper termination techniques is, however, are well beyond the scope of this application note. With this in mind, terminations will be briefly discussed in their simplest form as they relate to RS-485.

A terminating resistor is simply a resistor placed at the extreme end or ends of a cable (**Figure 4**). The value of the terminating resistor is ideally the same value as the characteristic impedance of the cable.

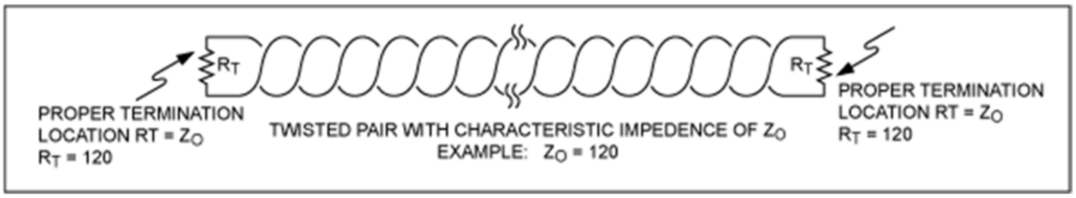


Figure 4. Termination resistors should be the same value of the characteristic impedance of the twisted pair and should be placed at the far ends of the cable.

When the termination resistance is not the same value as the characteristic impedance of the wiring, reflections will occur as the signal travels down the cable. This process is governed by the equation (Rt - Zo)/(Zo + Rt), where Zo is the impedance of the cable and Rt is the value of the terminating resistor. Although some reflections are inevitable due to cable and resistor tolerances, large enough mismatches can cause reflections big enough to cause errors in the data. See **Figure 5**.

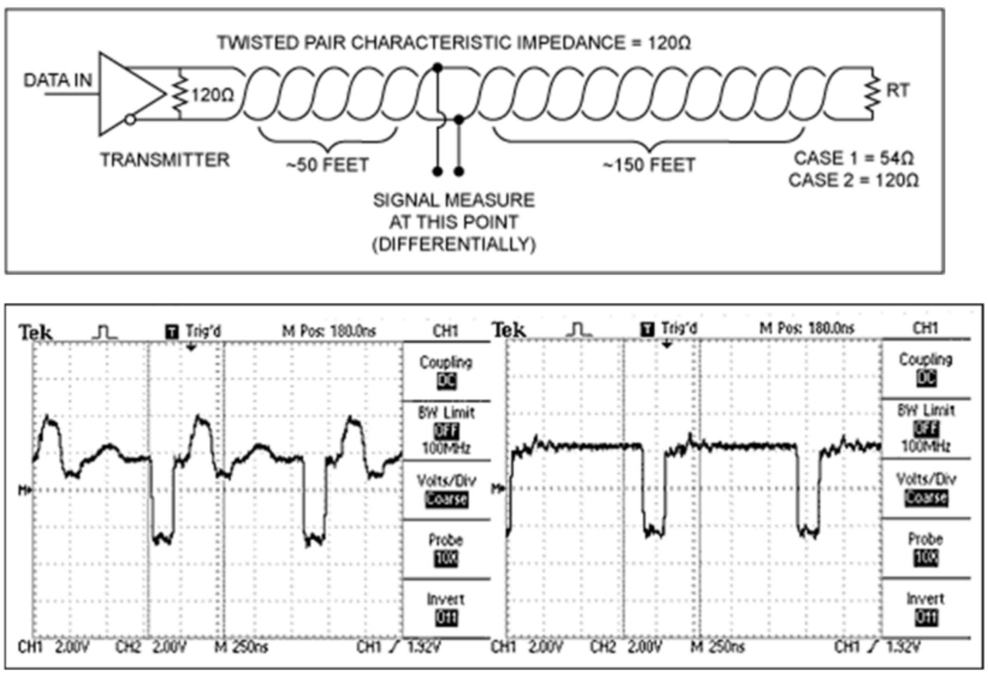


Figure 5. Using the circuit shown at the top, the waveform on the left was obtained with a 120Ω twisted-pair cable terminated with 54Ω. The waveform on the right was obtained with the cable terminated properly with 120Ω.

Knowing this about reflections, it is important to match the terminating resistance and the characteristic impedance as closely as possible. The position of the terminating resistors is also very important. Termination resistors should always be placed at the far ends of the cable.

As a general rule moreover, termination resistors should be placed at *both* far ends of the cable. Although properly terminating both ends is absolutely critical for most system designs, it can be argued that in one special case only one termination resistor is needed. This case occurs in a system when there is a single transmitter and that single transmitter is located at the far end of the cable. In this case there is no need to place a termination resistor at the end of the cable with the transmitter, because the signal is intended to always travel *away* from this end of the cable.

Maximum Number of Transmitters and Receivers on a Network

The simplest RS-485 network is comprised of a single transmitter and a single receiver. Although useful in a number of applications, RS-485 allows for greater flexibility by permitting multiple receivers and transmitters on a single twisted pair.[2] The maximum number of transceivers and receivers allowed depends on how much each device loads down the system. In an ideal world, all receivers and inactive transmitters will have infinite impedance and will not overload the system in any way. In the real world, however, this is not the case. Every receiver attached to the network and all inactive transmitters will add an incremental load.

Failsafe Bias Resistors

When inputs are between -200mV and +200mV, receiver output is "undefined". There are four common fault conditions that result in the undefined receiver output that can cause erroneous data:

- All transmitters in a system are in shutdown.
- The receiver is not connected to the cable.
- The cable has an open.
- The cable has a short.

Fail-safe biasing is used to keep the receiver's output in a defined state when one of these conditions occurs. The fail-safe biasing consists of a pull-up resistor on the noninverting line and a pull-down resistor on the inverting line. With proper biasing, the receiver will output a valid high when any one of the fault conditions occurs. These fail-safe bias resistors should be placed at the receiver end of the transmission line.

Some transceivers do not require fail-safe bias resistors because a true fail-safe feature is integrated into the devices. In true fail-safe, the receiver-threshold range is from -50mV to -200mV, thereby eliminating the need for fail-safe bias resistors while complying fully with the RS-485 standard. These devices ensure that 0V at the receiver input produces a logic "high" output. Further, this design guarantees a known receiver-output state for the open- and shorted-line conditions.

Examples of Proper Networks.

Given the above information, we are ready to design some RS-485 networks. Here are a few examples.

One Transmitter, One Receiver
The simplest network is one transmitter and one receiver (**Figure 6**). In this example, a termination resistor is shown at the transmitter end of the cable. Although unnecessary here, it is probably a good habit to design-in both termination resistors. This allows the transmitter to be moved to locations other than the far end, and permits additional transmitters to be added to the network if that becomes necessary.

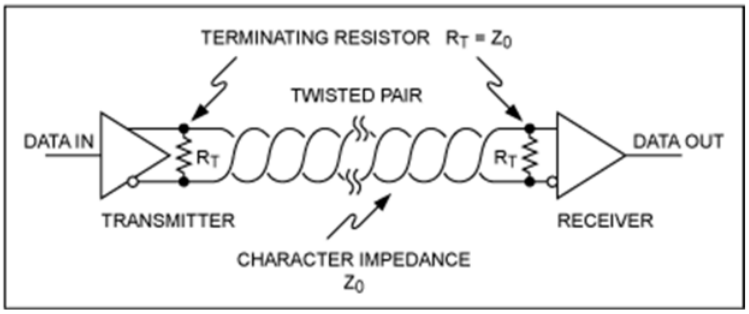


Figure 6. A one-transmitter, one-receiver RS-485 network.

One Transmitter, Multiple Receivers
Figure 7 shows a one-transmitter multiple-receivers network. Here, it is important to keep the distances from the twisted pair to the receivers as short as possible.

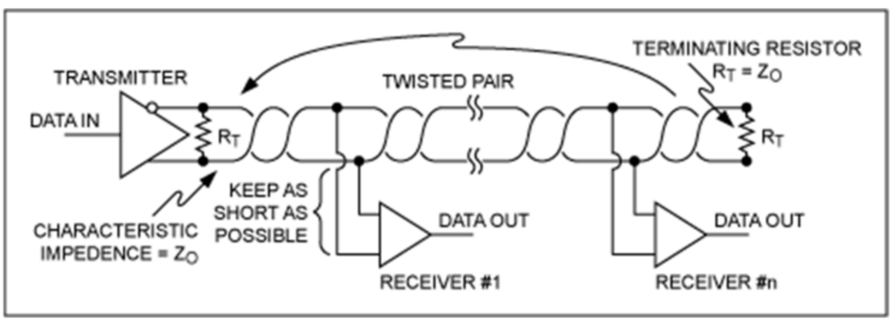


Figure 7. A one-transmitter, multiple-receivers RS-485 network.

Two Transceivers
Figure 8 shows a two-transceivers network.

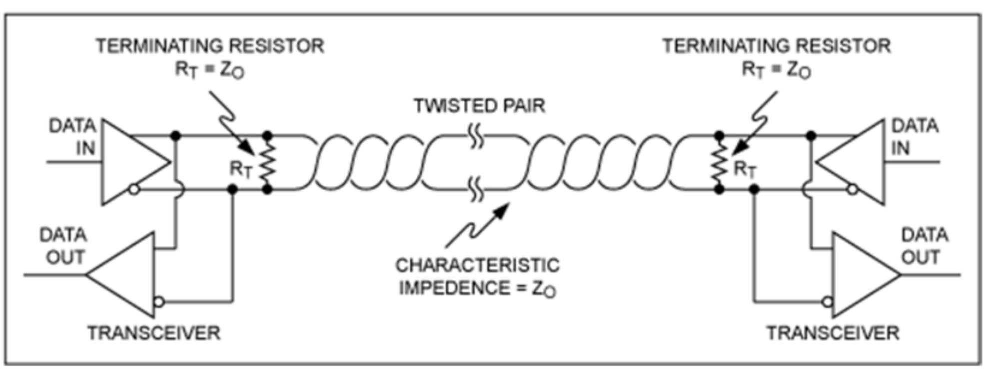


Figure 8. A two-transceivers RS-485 network.

Multiple Transceivers
Figure 9 shows a multiple-transceivers network. As with the one-transmitter and multiple-receivers example in Figure 7, it is important to keep the distances from the twisted pair to the receivers as short as possible.

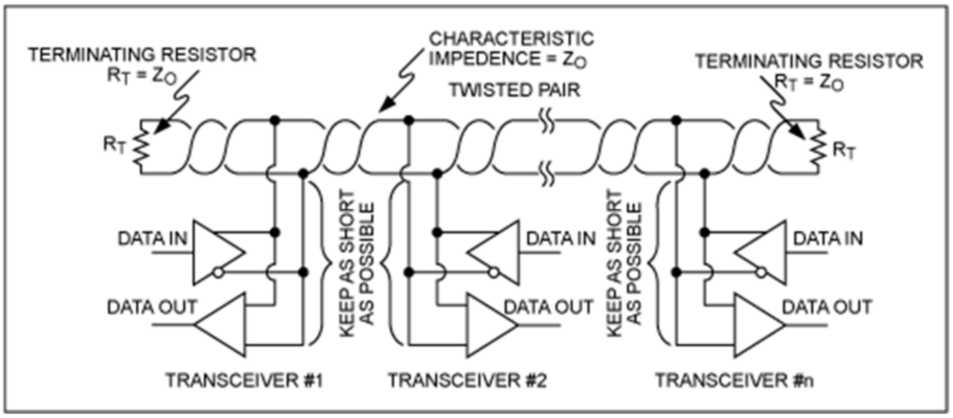
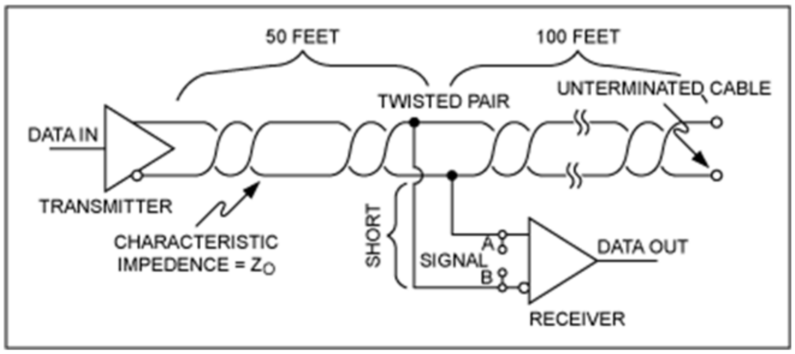


Figure 9. A multiple-transceivers RS-485 network.

Examples of Improper Networks.

The diagrams below are examples of improperly configured systems. Each example shows the waveform obtained from the improperly designed network, and compares that waveform from a properly designed system. The waveform is measured differentially at points A and B (A-B).

Unterminated Network
In this example, the ends of the twisted pair are unterminated. As the signal propagates down the wire, it encounters the open circuit at the end of the cable. This constitutes an impedance mismatch, thus producing reflections. In the case of an open circuit (as shown below), all the energy is reflected back to the source, causing the waveform to become very distorted.



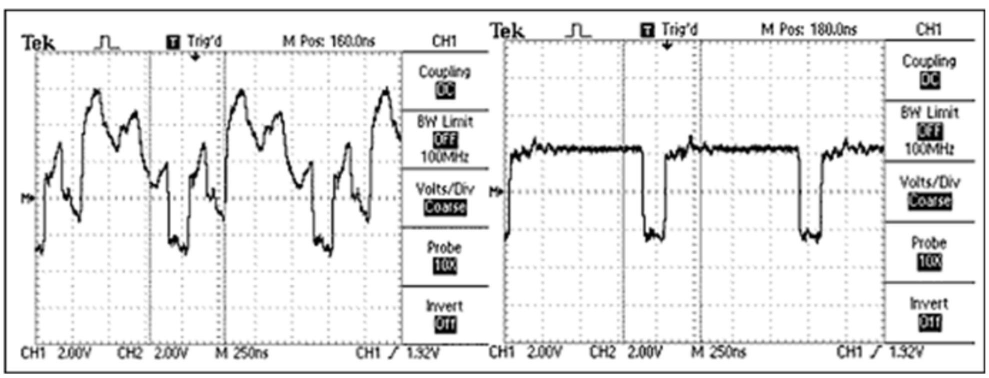


Figure 10. An unterminated RS-485 network (top) and its resultant waveform (left), compared with a waveform obtained from a correctly terminated network (right).

Wrong Termination Location
Figure 11 shows a termination resistor, but it is located in a position other than the far end of the cable. As the signal propagates down the cable, it encounters two impedance mismatches. The first occurs at the termination resistor. Even though the resistor is matched to the characteristic impedance of the cable, there is still cable after the resistor. This extra cable causes a mismatch and, therefore, reflections. The second mismatch is at the end of the unterminated cable, leading to further reflections.

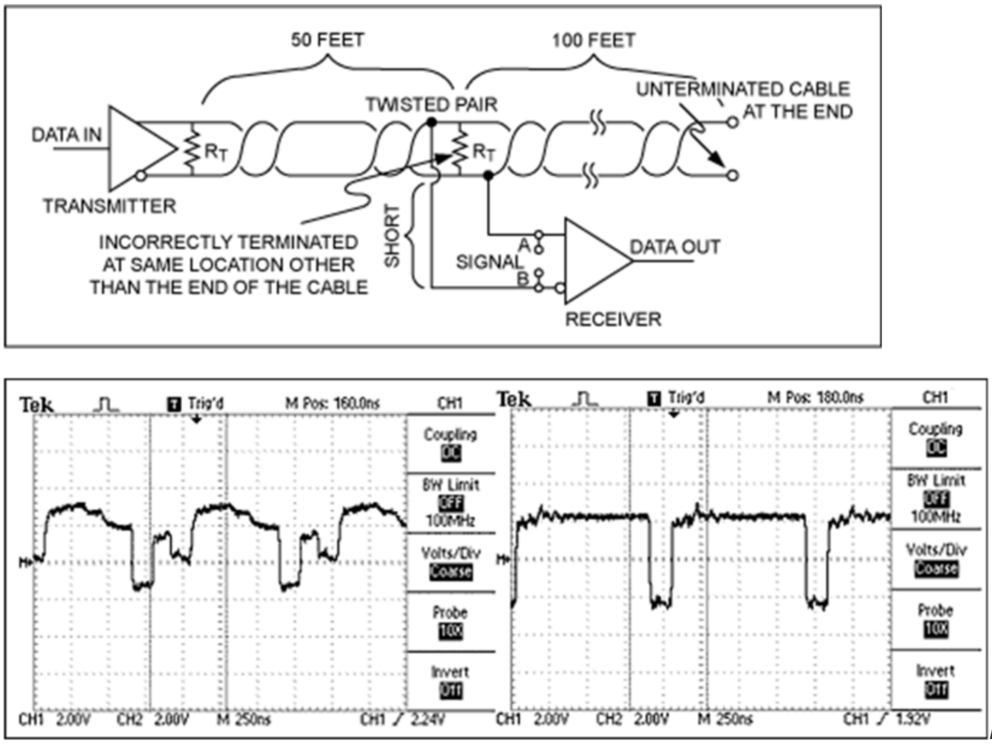


Figure 11. An RS-485 network with the termination resistor placed at the wrong location (top) and its resultant waveform (left), compared to a properly terminated network (right).

Multiple Cables

There are multiple problems with the layout in **Figure 12**. The RS-485 drivers are designed to drive only a single, properly terminated twisted pair. Here, the transmitters are each driving four twisted pairs in parallel. This means that the required minimum logic levels cannot be guaranteed. In addition to the heavy loading, there is an impedance mismatch at the point where multiple cables are connected. Impedance mismatches again mean reflections and, therefore, signal distortions.

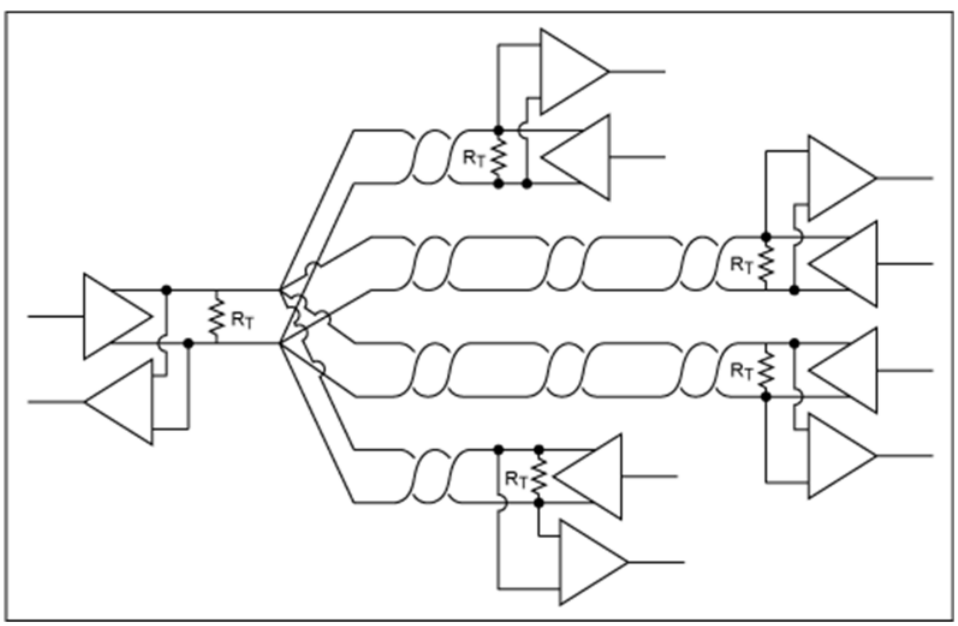


Figure 12. An RS-485 network that uses multiple twisted pairs incorrectly.

Long Stubs
In **Figure 13**, the cable is properly terminated and the transmitter is driving only a single twisted pair. However, the connection point (stub) for the receiver is excessively long. A long stub causes a significant impedance mismatch and thus reflections. All stubs should be kept as short as possible.

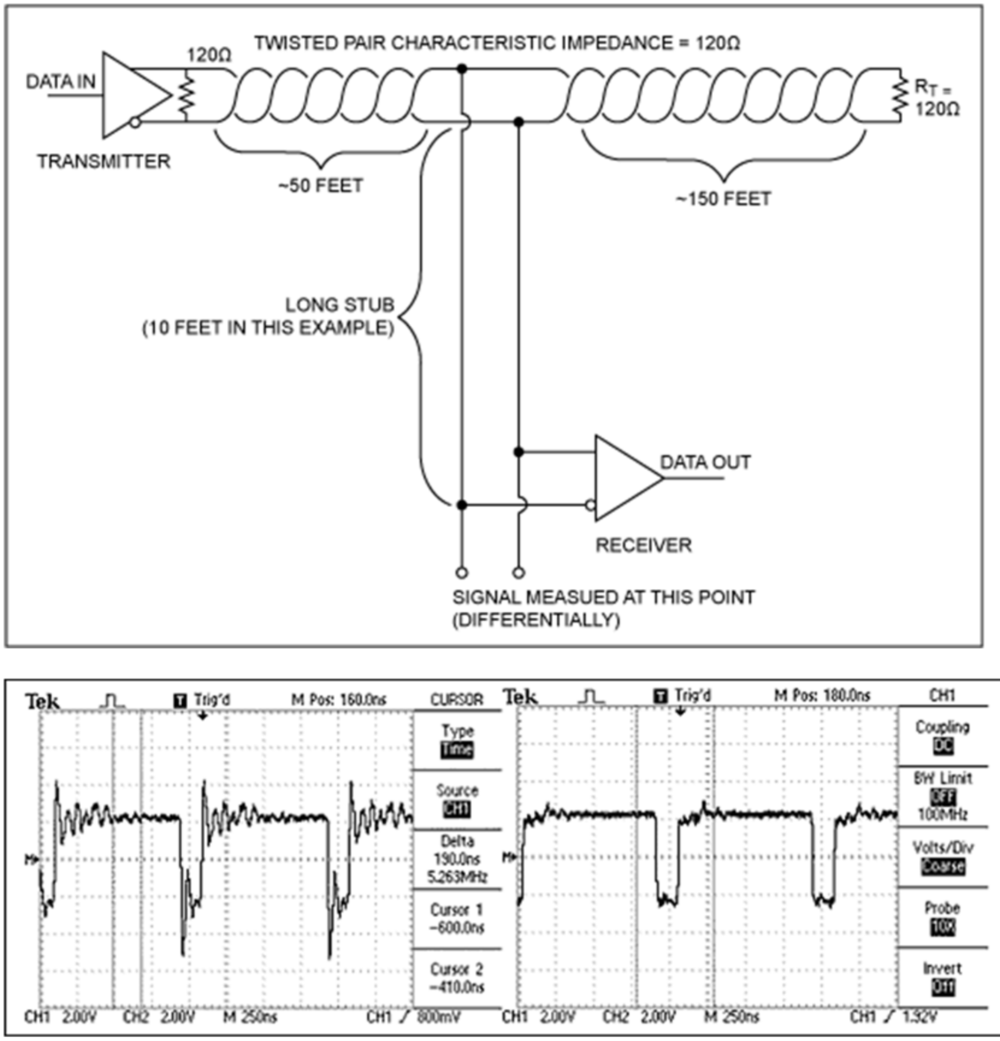


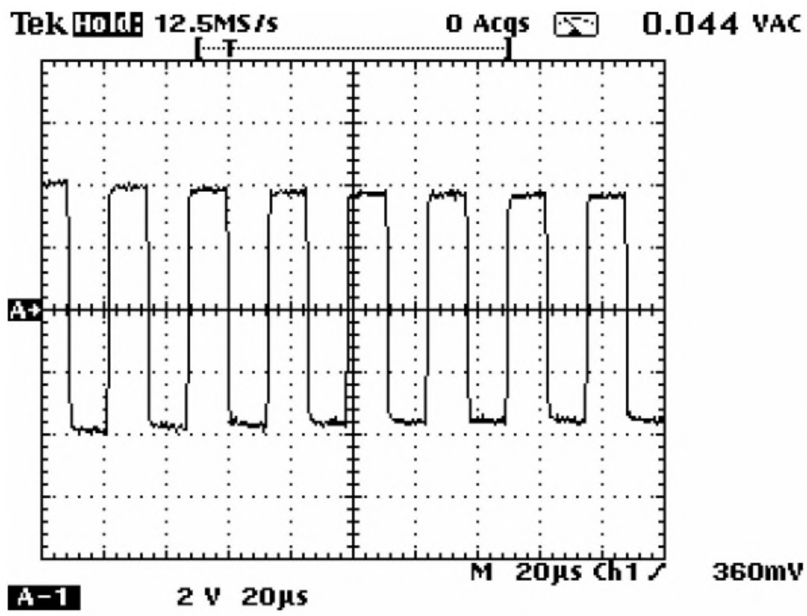
Figure 13. An RS-485 network that has a 10-foot stub (top) and its resultant waveform (left), compared to a waveform obtained with a short stub (right).

Examples of good and bad signals.

The following pictures are all measured directly "across" the bus, i.e. between the A and B signals on a Lon bus.

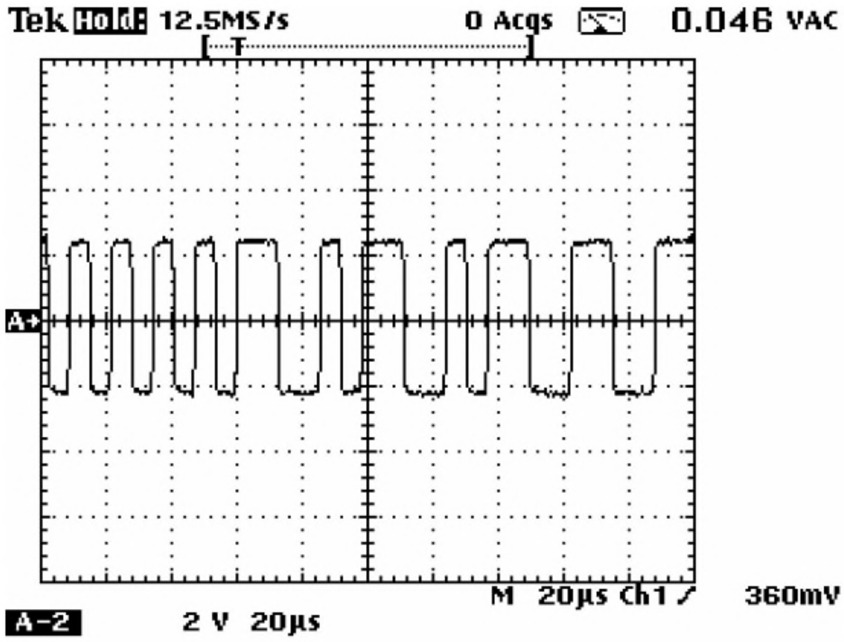
The pictures are made with a traditional Oscillscope, but measurements with the PicoScope will show the same amplitude and shape. Be aware of the Voltage/division and Time/division settings at the bottom of the pictures.

Very big signal (GW transmitting) - 8 Vpp, no noise.



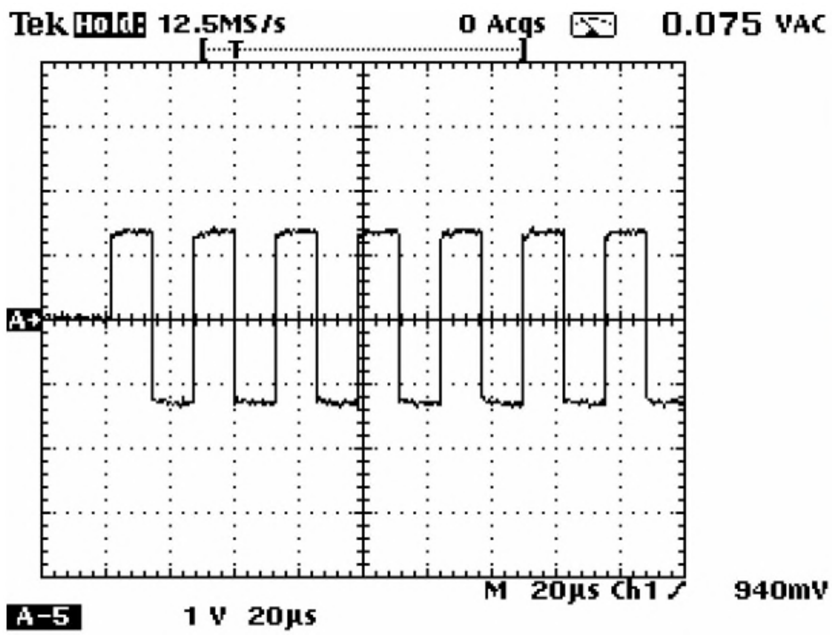
VERY GOOD

Good, but smaller signal (at other end of bus transmitting) – 4,5 Vpp



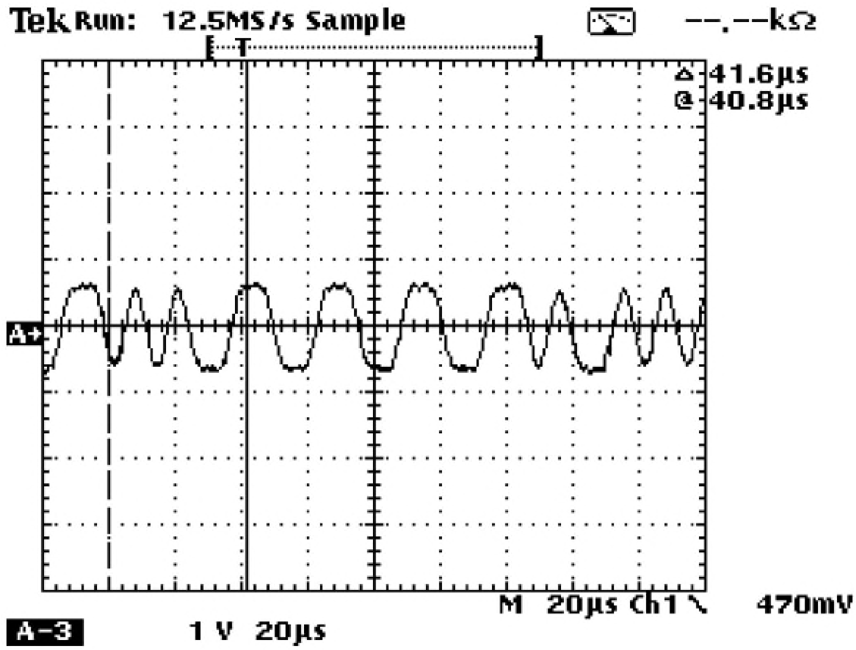
GOOD

Small but nice signal (note now 1 V/div). Signal level is small but sufficient, no noise is visible.



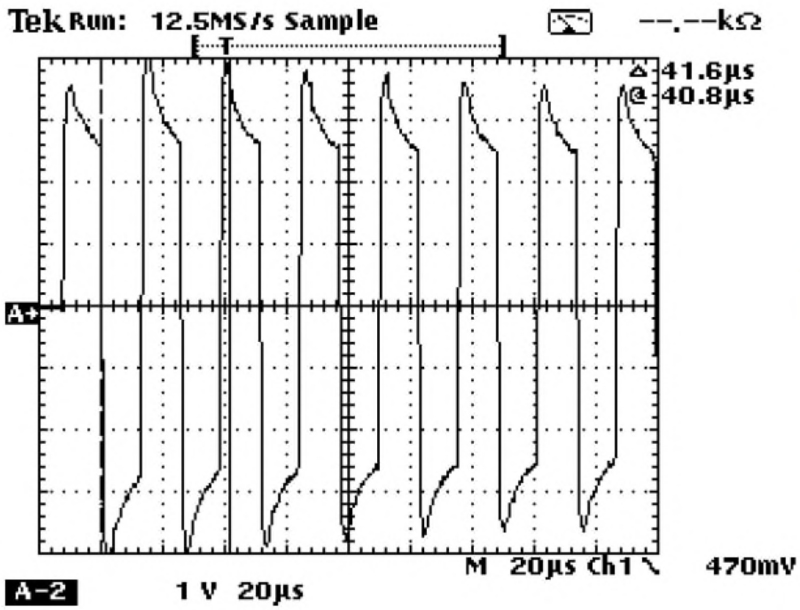
SUFFICIENT

Signal level very low and signals clearly distorted.


Tek Run: 12.5MS/s Sample
--.--kΩ
T
Δ 41.6µs
@ 40.8µs
A
M 20µs Ch1
470mV
A-3
1 V 20µs

BAD

Signal level good, but signals slightly distorted.

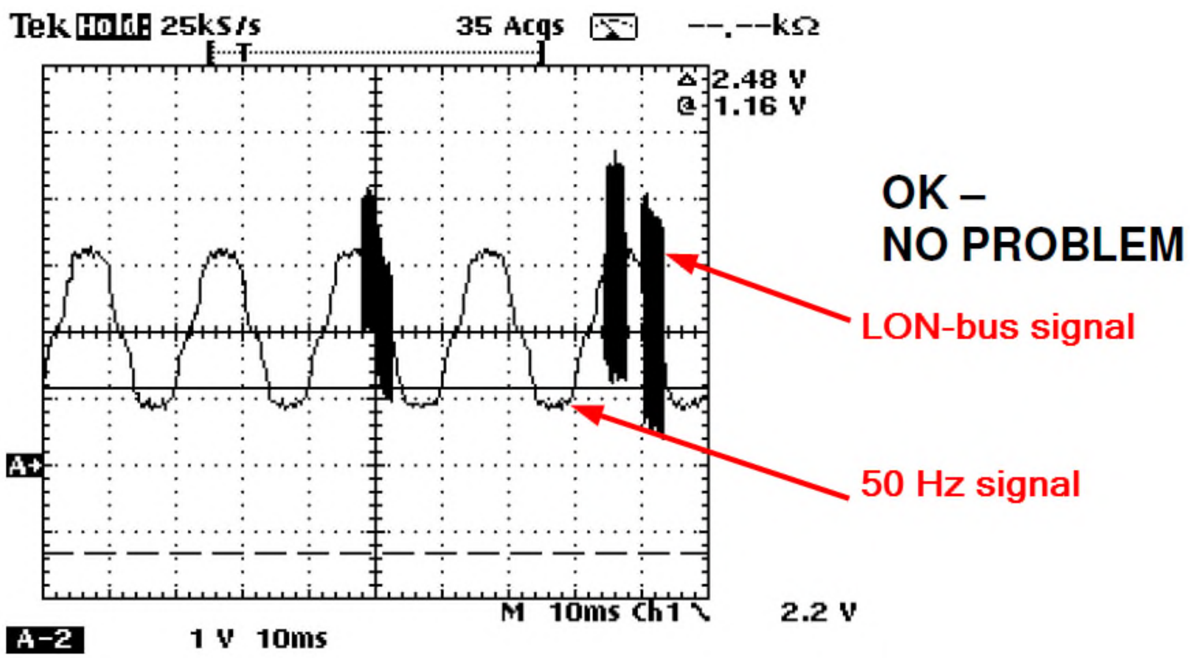


SMALL POSSIBILITY FOR PROBLEMS

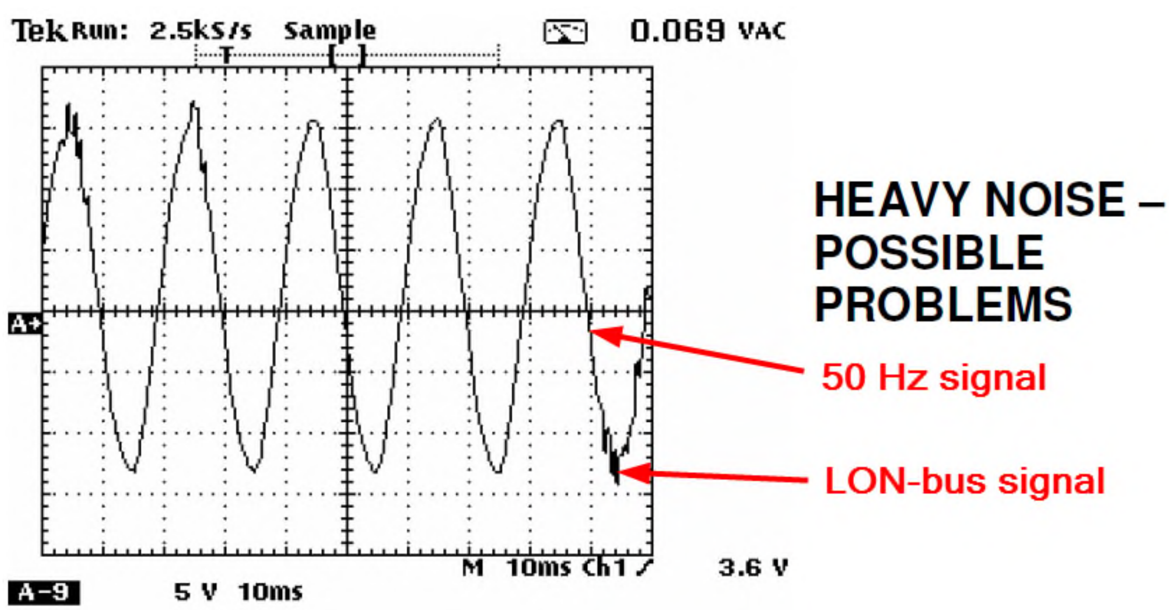
Another measurement that can indicate problems is to measure between "ground"- typically the metal cabinet in which the controller is mounted (e.g the DIN rail) and one of the Lon-signals (A or B terminal).
Normally this measurement will show some 50 Hz voltage with the LON communication signal overlaid.
If the 50 Hz noise level is too high compared to the MOD-bus signal (the overlaid signal), this can also cause severe problems.

The following two pictures are examples of this:

50 Hz noise comparable with Communication signals (2 – 3 Vpp) - No problem



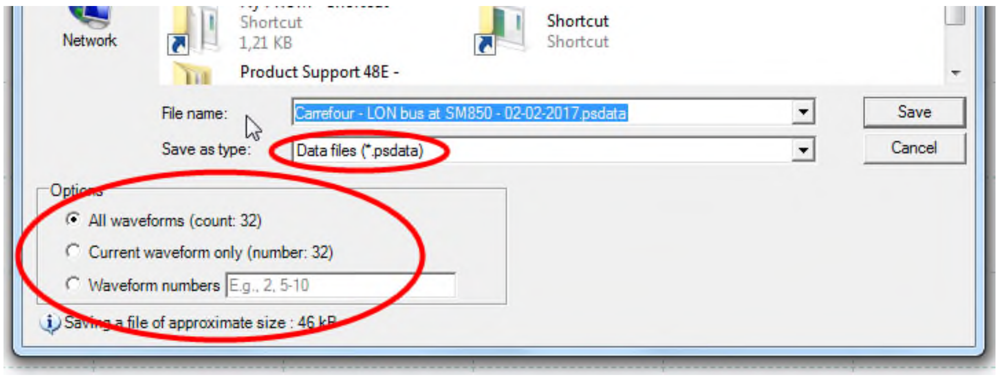
50 Hz Noise 10 X communication signals – will cause problems.



Saving measurements (screen shoots)

To save measurements follow the instructions below.

1. In the top-menu select "File" and "Save as"
2. Enter a describing File name



3. Select "Data files (*psdata)" in the "Save as type" field.
4. The PicoScope store the latest 32 screen views.
   It's possible to save all 32 screens (All waveforms), the current screen View (Current waveform only (number 32)) or selected screen views (waveform numbers) in the Option field. Check one of the 3 options.
5. When the file is saved it's possible to open it on a PC with Picoscope SW installed (connection of the Picoscope oscilloscope is not needed to view and analyse the "screen shoots")