AN1519
APPLICATION NOTE

STE400P / STE800P - TRANSFORMERLESS APPLICATION

1.0 INTRODUCTION

The purpose of this document is to enable a user to use ST's 4-port PHY (STE400P) or the 8-port PHY (STE800P) in a transformerless application. The STE400P / STE800P can be used to drive and to receive from a backplane that can consist of upto 1 meter of wires/board traces.

It can be assumed that the transmitted signal has a maximum frequency component of 125Mhz. The formula for calculating the wavelength is:

$$\lambda = \frac{c}{f_{max}}$$

where c is the speed of light and f_{max} is the maximum frequency of the signal.

f_{max} = 125 Mhz, hence we have:

$$\lambda = \frac{0.3\times10^9}{125\times10^6} = 2.4m$$

It is recommended that we should have matching impedance in place if the distance,

$$d > \frac{\lambda}{10}$$

Hence, in our case if the distance is greater than 24 cm., the impedance matching element should be placed accordingly on the receiving side.

2.0 TRANSMITTER

In the STE400P / STE800P devices, the ST patented CID driver that is used does not need any external resistors to provide impedance matching when used with an external transformer. The CID uses a 1.41:1 transformer and hence it is able to match the 100 Ohm line impedance when the transformer is in place. Without the transformer, the internal equivalent impedance is 200 Ohm.

The generation of the voltage signal is accomplished by sinking a current via the center tap of the primary winding of the transformer from the TX pins. At 100BaseT, this generates a voltage of about 1.4V on the primary and 1V on the line. When the transformer is removed, two load resistors need to be connected to VDD to ensure that the element converts the sinked current into voltage transmitted on the line.
The two 100 Ohm load resistors, are also being placed in parallel to the internal matching impedance element and hence, overall we are providing the transmitter with 100 Ohm equivalent impedance.

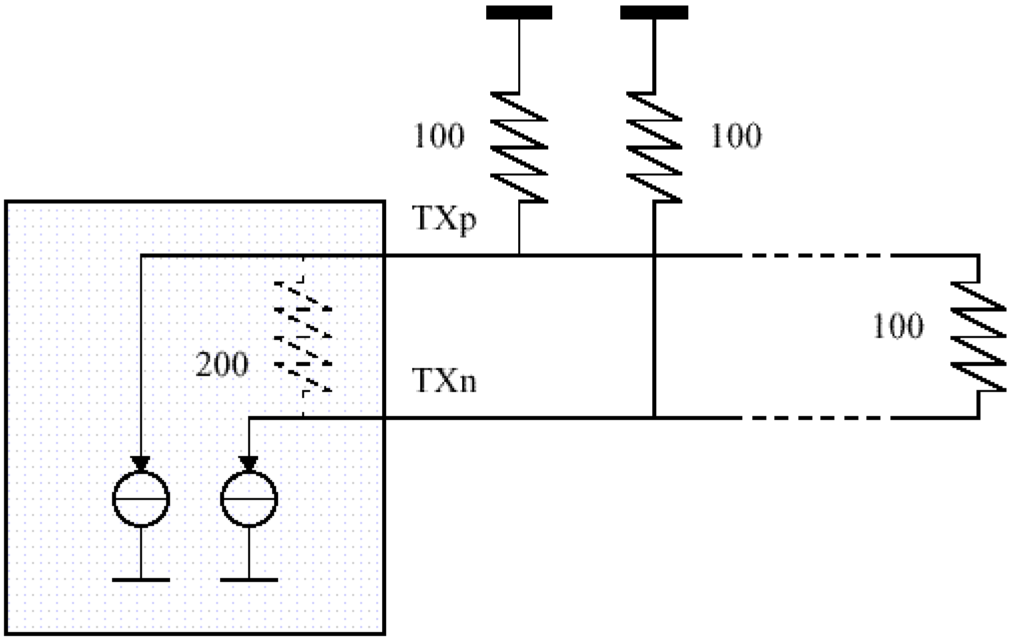


Figure 1: CID Output Impedance Matching

With such a resistor network, the current that the transmitter is capable of sinking will generate a signal of about 560mV signal. Therefore, a 560mVpp signal will be available at the output of the transmitter and also at the input of the receiver (The typical Ethernet signal is 1 Vpp). As the receiver can work only with fully differential signal, we need to provide fully differential signal at the output of the transmitter and this can be done by disabling the MLT3 features in the transmitter. The result is thus a fully differential signal of + / - 560mV at the output of the transmitter.

3.0 RECEIVER

Two main problems can be anticipated from the receiver side:

a) Common mode of the incoming signal

b) Level of the incoming signal can be much smaller in comparison to the typical Ethernet application

The possible solutions are discussed below.

The signal that is received from the transmitter is generated by sinking the current from resistors connected to VDD (3.3V). The common mode signal that is arriving to the receiver should be in the range of 1V and so decoupling capacitors will be needed to avoid conflict between the TX and RX common mode signal. This will resolve the common mode issue, but can introduce a Baseline Wander (BLW) problem. The decoupled signal may be affected by the BLW and the BLW compensation circuit used will not be able to correct it because the signal will not be in MLT3 format. (The BLW compensation circuit assumes the MLT3 format and does not work correctly with the NRZI signal. So, we need to disable the BLW signal as well.)

Consequently, using the NRZI signal, we are able to better decode the received signal even in the presence of BLW.

Another assumption made is that at these frequencies the transfer function of the board wires is practically flat

(1 or 2 dB of attenuation) and so the signal that is produced at the transmitter arrives unchanged at the receive side. In the transformerless application, as the level of the signal is lower than the expected, the equalizer will try to amplify it by applying the transfer function that is forecast for the Cat5 cable that is generating such attenuation. This will destroy the signal and we will be not able to recover it.

So, at start up, the equalizer should be set to tap 0 allowing the device to recognize the data and provide the clock recovery. This can be done by writing 0x0800 to PHY Register 11 (0x0B) This should be written to the register for each port being used in the application. By setting the equalizer tap to 0, we assume that valid data is already on the line. If this is not true, after the first 600usec, whatever is at the output of the equalizer will be available at the clock recovery. If this fails to lock to the right frequency (as in the case where there is no data available on the line) the equalizer is reset and after 600usec the procedure will restart till the data is present and valid. This can generate some fluctuations of the link signal at the start up phase. This can be avoided if the Tx signal is present before this 600usec of time delay.

So we should make sure that:

a) Auto negotiation must be disabled

b) TX switched on before RX

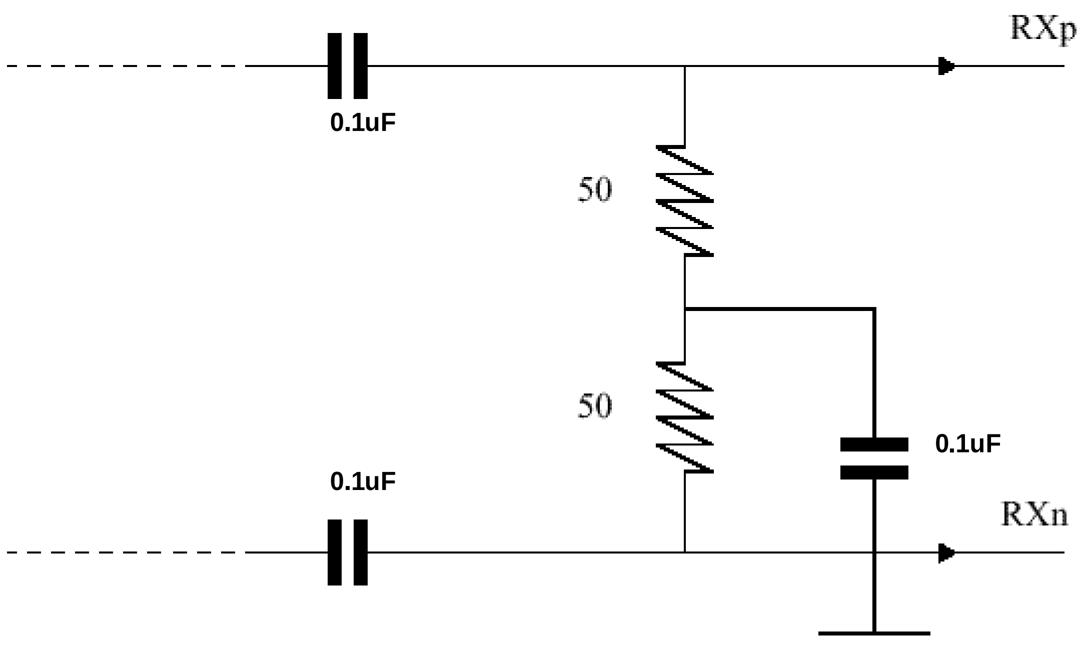


Figure 2: Example of components to be connected to the Receiver inputs of the STE400P / STE800P

4.0 SUMMARY OF SETTINGS NEEDED FOR A TRANSFORMERLESS APPLICATION

The main modifications to be made when the STE400P / STE800P are used in a transformerless application are as follows:

- Impedance Matching on the board
- MLT3 disabled (Set bit 15 = 0 of test register at 0x14)
- BLW correction disabled (Set register PR9 at 0x10, bit 16 = 1)

- Equalizer set to tap 0 (Write 0x0800 to PHY Register 11 for each port being used in the application)
- Autonegotiation disabled (Set Register PR0 bit 12 = 0)
- TX switched on before RX

5.0 TESTING

Sample Testing of a transformer less application was done with the STE400P evaluation board with upto a five meter Cat 5 cable. The STE400P board was configured according to the recommended transformerless application requirements (Impedance matching resistors added and MLT3, BLW compensation, Equalizer set to tap 0, Auto-negotiation disabled and TX switched on before RX - See above sections). Below are results of a sample test.

Equipment Used:

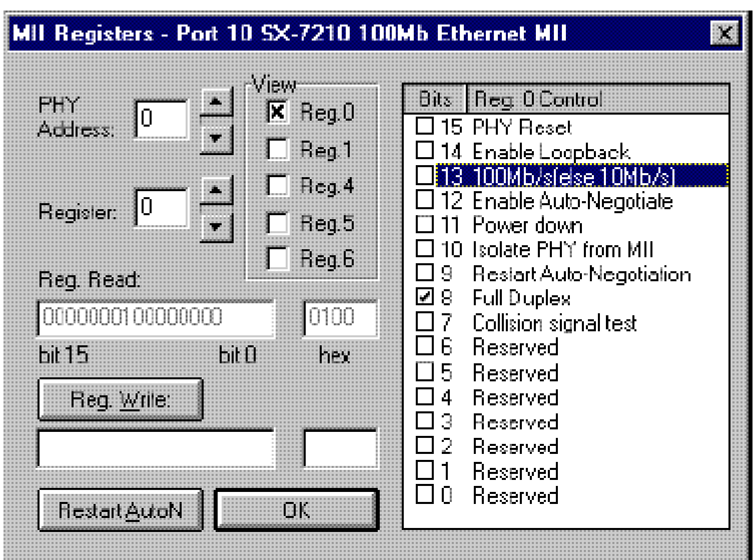
1. One meter Cat 5 Crossover cable

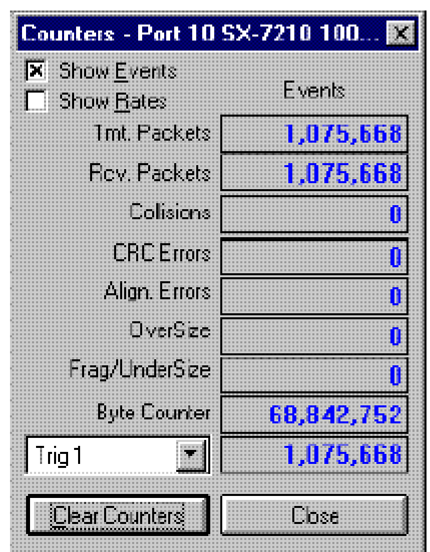
2. Spirent / Netcom SmartBits 2000 Performance Analysis System

3. ST's STE400P Evaluation Board

Setup for the STE400P board for 10Mbps, full duplex, transformerless operation. The board was configured to Transmit from Port 3 and Receive on Port 4.

Cable Length =1m.
Results were: No loss of packets or errors, as shown below:

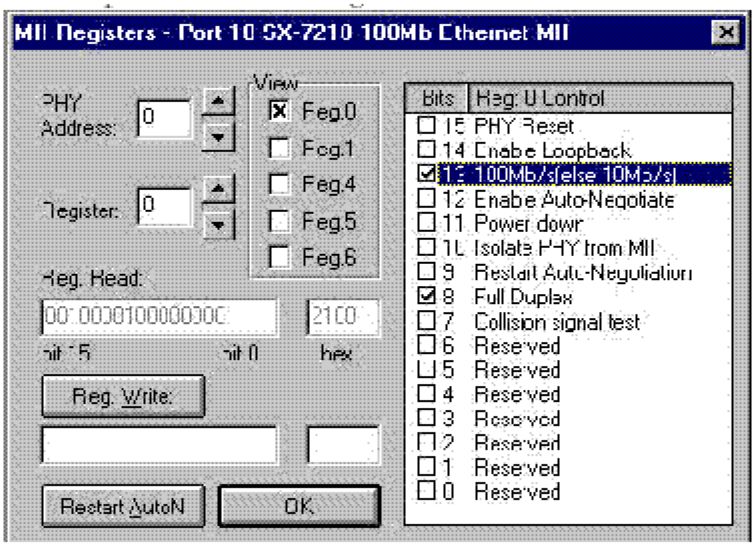


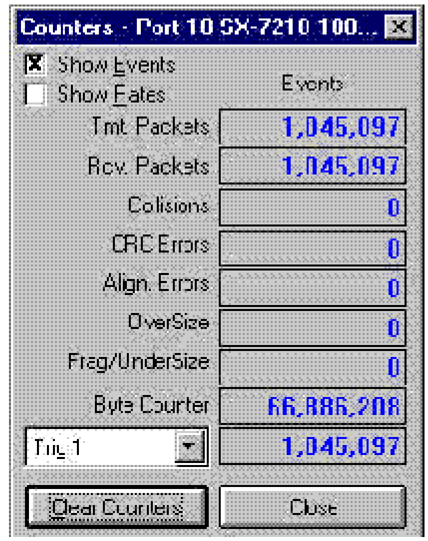


This test was repeated with Cable length = 5m and results were equivalent : No loss of packets or errors.

Setup for the STE400P board for 100Mbps, full duplex, transformerless operation. The board was configured to Transmit from Port 3 and Receive on Port 4.

Cable Length = 1m.
Results were: No loss of packets or errors, as shown below:





This test was repeated with Cable length = 5m and results were equivalent : No loss of packets or errors.

Hence, it can be verified that the STE400P device is able to transmit and receive correctly without the transformers at both 100BaseT as well as at 10BaseT operating modes.