

# **How to use the TDR Feature of DP83822**

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## **ABSTRACT**

This document describes the TDR functionality of Ethernet PHYs with focus on DP83822. The application report explains TDR in brief and then describes how to use this feature for cable diagnostics.

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## 1 Introduction

As Ethernet networks grow more and more complex, detecting link and cable faults becomes more difficult. The need for cable diagnostics tools is more important than ever. The cables used can be very long in length and the topologies can be complicated so the cable diagnostics tools need to be non-intrusive. TI's ethernet PHYs provide solution to this problem with diagnostic tools integrated in the PHY.

## 2 Time Domain Reflectometry

### 2.1 TDR

TDR can be used for cable diagnostics when the Link is down. TDR involves sending a pulse on TX and RX pair and observe results on either pair. By measuring voltage amplitude, polarity, and time interval the PHY can determine the nature and position of the fault. This feature works under certain conditions like;

- Cable Open
- Cable Short
- Link Partner Down
- TX/RX pair cross-wired
- Impedance discontinuity

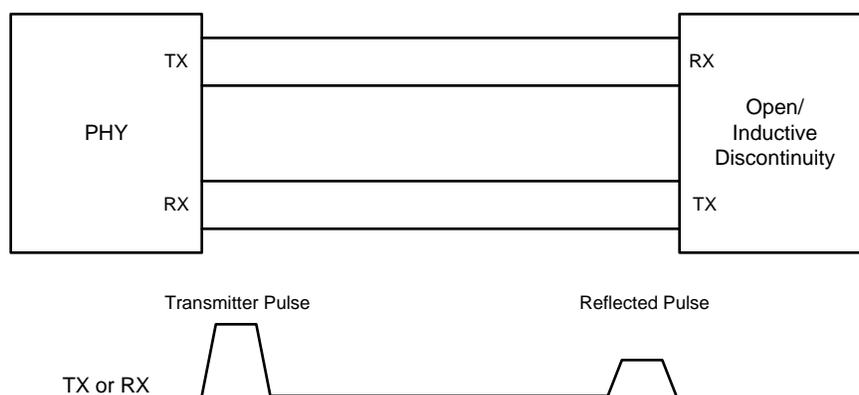
TDR works for only for twisted pair connections. TDR generator will send pulse on the TX and RX channel and then monitor both channels to observe reflections. It will send a pulse on one channel at a time and if reflections are observed on the other channel then the PHY realizes that the wires have been crossed. DP83822 can detect 5 peaks on TX and RX channels each.

### 2.2 Example Connections

Following are the example connections where TDR can be used.

#### 2.2.1 Open Circuit Cable

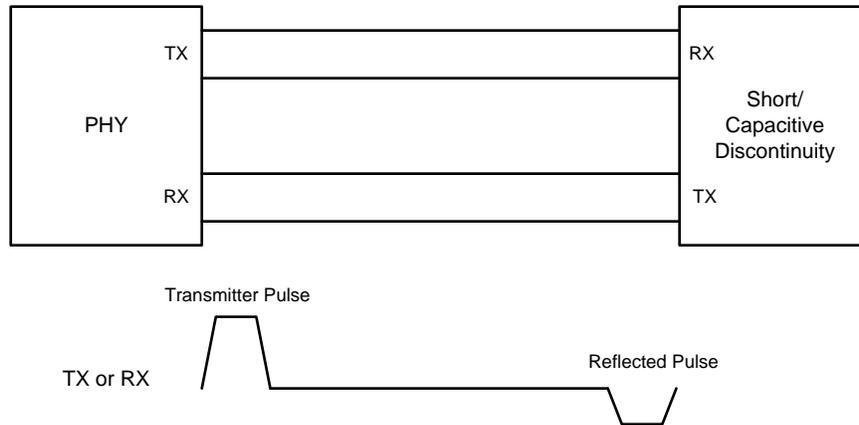
Open cable is easy to diagnose as it will generate a strong reflection. No reflection will be observed on the other channel. The reflection due to open circuit will be in-phase with the transmitted pulse (positive polarity). Any kind of inductive impedance discontinuity will generate in-phase reflection and the amplitude will depend on the amount of impedance discontinuity.



**Figure 1. Open Circuit Cable**

### 2.2.2 Short Circuit Cable

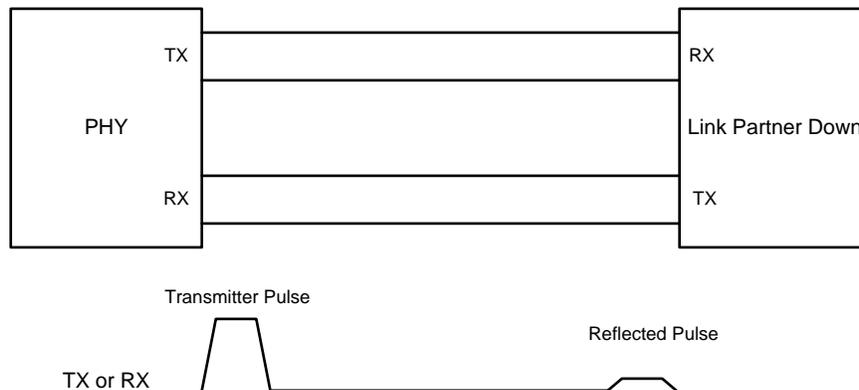
Short Circuited cable will also generate a strong reflection but this reflection will be out of phase with the original pulse (negative polarity). Any kind of capacitive impedance discontinuity will generate out of phase reflection and the amplitude will depend on the amount of impedance discontinuity.



**Figure 2. Short Circuit Cable**

### 2.2.3 Link Partner Down

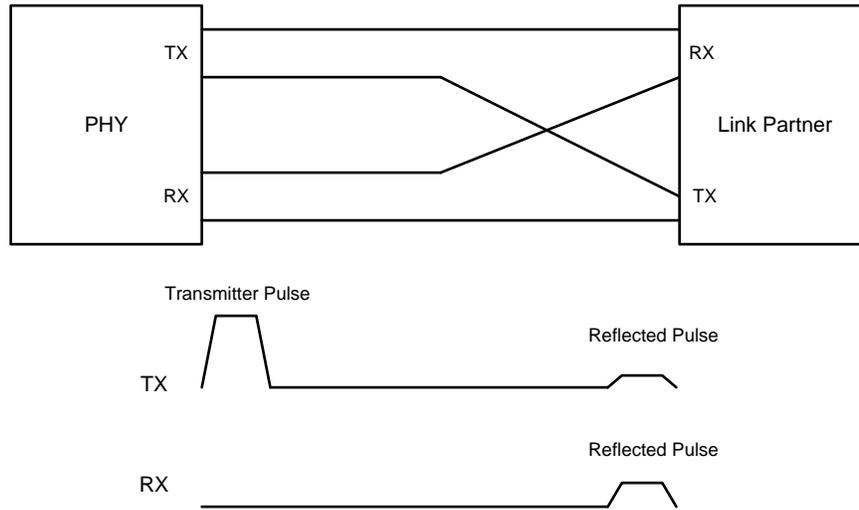
When the Link partner is in power down mode or inactive the line will be terminated. In an ideal scenario, the termination will be perfectly matched with no reflection but this is very difficult to achieve. In reality there will be small reflections due to some impedance mismatch. For longer cables, this reflection is not strong enough to make cable length measurements.



**Figure 3. Inactive Link Partner**

### 2.2.4 Cross-Wired Cable

Due to incorrect cable or connector assembly, a single wire from TX or RX differential pair is routed to the opposite channel. This results in an unexpected return pulse on the channel not being tested. For e.g. If transmit channel is being tested in a cross-wired cable then a unexpected return pulse will be observed on the receive channel. To check for this, the PHY observes both the channels even if sends a pulse on one channel at a time. In addition to return pulse on the other channel there can be a return pulse on the channel under test.



**Figure 4. Cross-Wired Cable**

## 2.3 TDR Implementation

For the purpose of this document, TDR implementation in DP83822 will be discussed.

### 2.3.1 TDR Configuration

TDR can be configured to run automatically after Link Drop through Register 0x0009 bit 8 or run manually from Register 0x001E bit 15.

For using TDR, following register writes are required.

- Write 0b1100 to bits [3:0] of register 0x0171
- Write 0b11111111 to bits [15:8] in register 0x0173
- Write 0b000011000 to bits [12:8] in register 0x0177
- TDR Auto-run from bit [8] in register 0x0009 or manually start TDR using bit [15] of register 0x001E

TDR status is stored in bits [1:0] of register 0x001E. TDR results are stored in registers 0x0180 to 0x018A. Basic software processing is required for converting register values to physical quantities. Ignore values in Cable Diagnostics Registers that read 0b1100.

### 2.3.2 Cable Length and Fault Location

DP83822 can detect 5 peaks on TX and RX channels each. Running TDR on a open ended cable will let users estimate the cable length. Any impedance discontinuity in the cable will generate reflections which can be used for detecting the location fo the fault. Peak locations are stored in registers 0x0180 to 0x0184. Every register contains 2 peaks with 8 bits allocated for every peak. Following process can be used for finding the peak location in meters.

- Read bit [1:0] from Register 0x001E to ensure that TDR was successfully completed.
- Read registers 0x0180 to 0x0184 to get TX and RX peak locations.
- Convert Hex Value of a peak to Decimal Value(DV).
- Find the Intermediate Location (IL) =  $(DV \times 0.8621) - 8$
- Find Final Location(FL) in meters =  $IL + ((70 - IL) \times 0.01)$

For e.g lets assume that after running TDR, only one peak was observed on the Transmit path. Register 0x180 reads 0x0033.

- Convert peak 1 location from hexadecimal to decimal. 0x33(hex) -> 51(dec)
- $IL = (51 \times 0.8621) - 8 = 35.97$
- $FL = 35.97 + ((70 - 35.97) \times 0.01) = 36.31m$

This is now the location of the fault. If it is known that this is a open ended cable with no breaks then the length obtained is the length of the cable.

### 2.3.3 Peak Amplitude and Polarity

Peak amplitude is stored in registers 0x0185 to 0x0189. Every register contains amplitudes for 2 peaks with 8 bits allocated for every peak. Convert the register value from Hexadecimal to Decimal and divide it by 256.

Polarity of all peaks is stored in Register 0x018A bit [15:6]. Bit value of '0' indicates a positive peak and bit value of '1' indicates a negative value. Register 0x18A also has bits to indicate if the TX and RX channels have been cross wired. Bits [3:2] will indicate if more than 5 peaks were detected on TX and RX channel respectively.

## 3 Conclusion

This app note explains the basics of TDR and how to use the TDR functionality of the DP83822 Industrial Ethernet PHY.

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