Application Report

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Solving Cable Faults Challenges with TI Ethernet PHYs

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ABSTRACT

This app note outlines how Time Domain Reflectometry helps solving various kind of cable fault challenges of Ethernet based communication systems. The app note describes the procedure to use TDR feature of DP8325I for implementing cable diagnostics feature in system.

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Trademarks

1 Time Domain Reflectometry

1.1 TDR

TDR works for only for twisted pair connections. 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. DP83825I 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 TDR realizes that the wires have been crossed. DP83825I can detect 1 peak for each transmit and receive channel. TDR can be used for

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

TDR can be used only when the Link is down.

1.2 Example Connections

Following are the example connections where TDR can be used.

1.2.1 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.

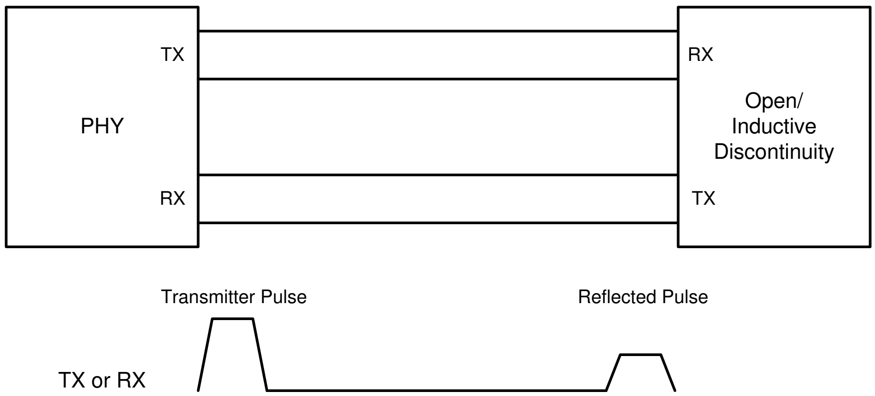

Figure 1. Open Circuit Cable

1.2.2 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.

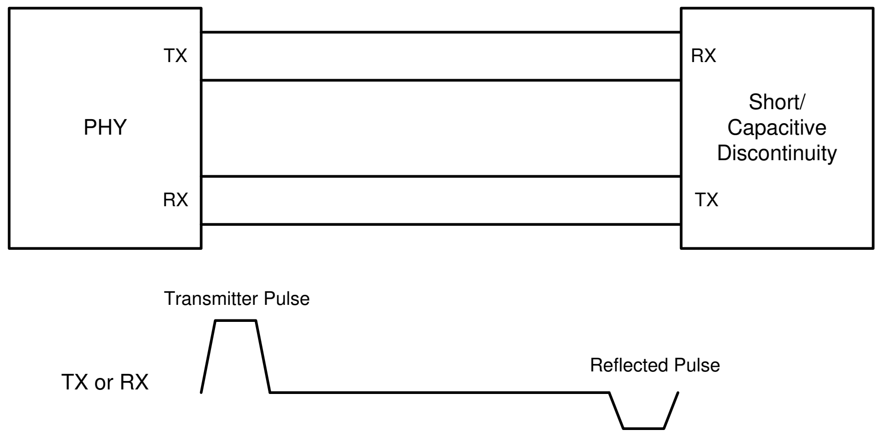

Figure 2. Short Circuit Cable

1.2.3 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.

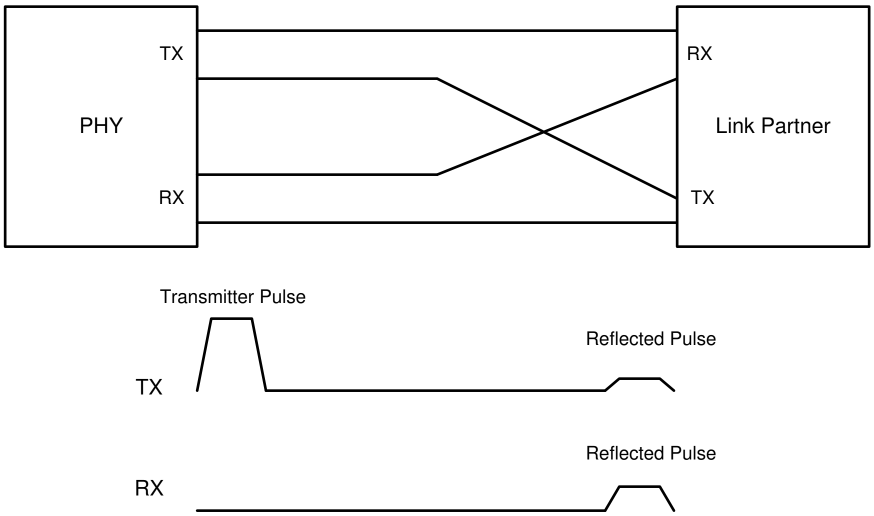

Figure 3. Cross-Wired Cable

2 DP83825I TDR configuration

DP83825I can support cable reach of 150 meter and above. Long cable reach causes transmitted signal to face higher attenuation with cable length so the gain and other settings need to be tweaked with cable length to achieve reliable fault detection using TDR. Hence the cable is assumed to be divided into 5 segments as follows

Segment 1 – 0m to 10m

Segment 2 – 10m to 20m

Segment 3 – 20m to 40m

Segment 4 – 40m to 80m

Segment 5 – 80m to 190m

Based on the length of cable in the use case, TDR can be run for relevant cable segments.

For each cable segment it can have 4 combinations of transmit and receive since it can have 2 channels which means 4 iterations of TDR for each segment. For each such iteration of TDR location, amplitude, sign of peak (if reported) should be stored until all cable segments are covered.

For each segment software shall configure the PHY with register settings given in table below and TDR process for that segment should be started by writing Register 0x001E bit 15 -

Table 1.

Segment 2		Segment 3	Register	Segment 4	Segment 5
0x3		0x3	0x456[10:9]	0x9	0x3
0x13		0x15	0x411[4:0]	0x16	0x16
0xA		0xA	0x416[7:4]	0x4	0x9
0x1C22		0x1E32	0x170[12:0]	0x1E42	0x1E52

Table 1. (continued)

Segment 2		Segment 3	Register	Segment 4	Segment 5
0x0D14		0x0D14	0x173	0x343B	0x8F6F
0x1004		0x1004	0x175	0x1008	0x100B
0x2		0x2	0x178[2:0]	0x2	0x6

For every segment, 4 combinations of transmit and receive can be configured by

– Transmit on A, Receive on A : 0x170[14:13] = 2’b10

Transmit on A, Receive on B : 0x170[14:13] = 2’b00

Transmit on B, Receive on A : 0x170[14:13] = 2’b01

Transmit on B, Receive on B : 0x170[14:13] = 2’b11

3 Fault location and type

For each iteration, software needs to wait until Register 0x001E Bit 1 is set indicating TDR is completed.

If TDR Register 0x001E Bit 0 is set, it means this iteration of TDR has failed with possible reasons being noise on the line, link already being established etc.

If this bit is not set, TDR is successfully completed. If Register 0x0185 Bit [6:0] show non zero value it means a peak was reported for this TDR iteration, once a peak is reported software can store peak location (0x0180[7:0]) and peak sign (0x018A[11]).

Similarly this process has to be repeated for 4 transmit/receive channel combinations and for all cable segments.

If TDR is run for all cable segments software may have to store information of maximum 20 peaks.

If no peaks are reported across all iterations, no fault has been reported by TDR mechanism. If atleast 1 peak is reported cable has fault, software should discard all peaks reported in higher cable segments and use the following table to identify fault type using peak information from peak observed in lowest cable segment –

Table 2.

TX =A, Rx =B			TX =B, Rx =A		Fault type	Tx=B, Rx=B	
Peak		Sign	Peak	Sign		Peak	Sign
No		-	No	-	Both Open	Yes	1'b0
No		-	No	-	Both Short (to VDD/Gnd/between P-N)	Yes	1'b1
Yes		1'b1	Yes	1'b1	Cross Short	Yes	1'b1

Location of this fault can be calculated by using the peak location value from Register 0x180[7:0] for the first encountered peak using following

1. Convert 0x180[7:0] to decimal value(DV)

2. Round off (DV-7)/1.3 to nearest integer, call it PL

3. PL is location of peak in meters

4 Summary

This app note explains the basics of TDR and how to use the TDR functionality of the DP83825I Industrial Ethernet PHY.

5 References

- DP83825I Datasheet